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JOURNAL OF PALEONTOLOGY

A Publication of

The Society of Economic Paleontologists and Mineralogists
A Division of the American Association of Petroleum Geologists
and
The Paleontological Society
An Associate of the Geological Society of America

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JOURNAL of PALEONTOLOGY

RAYMOND C. MOORE AND C. WYTHE COOKE
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The JOURNAL OF PALEONTOLOGY is published semi-quarterly by the Society of Economic Paleontologists and Mineralogists, a division of the American Association of Petroleum Geologists, and by the Paleontological society, associated with the Geological Society of America.

The subscription price of the JOURNAL OF PALEONTOLOGY is $6.00 per year prepaid to addresses in the United States, Mexico, Cuba, Porto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, El Salvador, Bolivia, Colombia, Honduras, Nicaragua, Peru, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands.

Single numbers, $2.00 each.

Postage is charged extra: For Canada, 20 cents on annual subscriptions (total $6.20), and for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

Claims for non-receipt of preceding numbers of the JOURNAL must be sent to the Secretary-Treasurer within three months of the date of publication in order to be filled gratis.

The JOURNAL will furnish reprints at cost. Orders should accompany corrected galley proof.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and advertising should be addressed to Henry V. Howe, Louisiana State University, Baton Rouge, Louisiana.

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Entered as second-class matter at the Post Office at Fort Worth, Texas, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in paragraph 4, section 538, P. L. and R., authorized April 3, 1935.

Additional entry as second-class matter at the Post Office at Menasha, Wis.

GEORGE BANTA PUBLISHING COMPANY, MENASHA, WIS.

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JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 4, PP. 261–275, PLS. 36, 37, TEXT FIGS. 1–3, JUNE, 1937

CRETACEOUS RUDISTIDS OF PINAR DEL RIO PROVINCE, CUBA

L. W. J. VERMUNT

ABSTRACT

This paper describes several rudistids collected in western Cuba from which until now only *Barrettia sparcilirata* Whitfield and *Chiapasella pauciplicata* Müllerried have been known. New species, *Orbignya müllerriedi*, *Biradiolites tschoppi*, *Biradiolites macgillavryi*, *Bournonia thiadensi*, *Durania palmeri* and *Tampsia rutteni*, are all of Upper Cretaceous, probably Maestrichtian, age.

In the summer of 1933 some geologists from the University of Utrecht, under the leadership of Prof. L. M. R. Rutten, visited Pinar del Rio Province in western Cuba, in order to make a geological survey of this region. Many rudistids were collected from Upper Cretaceous limestone layers, the greater part of the shells having been weathered out. Although the rudistids occur at many localities only the well-preserved specimens are recorded in this paper. The collecting localities are indicated on the accompanying map. The letters L, M, H, A, and V, preceding the field numbers, indicate, respectively, the collectors L. M. R. Rutten, M. G. Rutten, H. J. MacGillavry, A. A. Thiadens, and L. W. J. Vermunt.

On the basis of occurrence of orbitoids, M. G. Rutten (1936) established a Maestrichtian age for the rudistid-bearing strata in northern Santa Clara Province. At two localities in Pinar del Rio, near L818 and at M940, orbitoids of Maestrichtian age (*Orbitoides browni* (Ellis)) are also associated with the rudistids. It is highly probable that the other rudistid faunas are of the same Maestrichtian age.

Through the courtesy of the Bataafsche Petroleum My., I received some rudistids collected by Doctor Tschopp at San Diego de los Baños and north of San Juan y Martinez. In the following table, which records the faunas of the different localities, these specimens are reckoned to have been found at H787 and H774, our localities near San Diego and north of San Juan, but they have been marked differently (O) in the table. I have had much help from Mr. H. J. MacGillavry in study of the material here described, for which I am greatly indebted to him.

SYSTEMATIC DESCRIPTIONS

Genus ORBIGNYA Woodward, 1862

ORBIGNYA MÜLLERRIEDI Vermunt, n. sp.

Plate 36, figures 1–3; Text figures 3*a–d*

Hippurites (*Orbignya*) sp. TRECHMANN, *1924*, Geol. Mag., vol. 61, no. 723, pp. 396, 397, pl. 23, fig. 5.

Orbignya cf. *incisus* MÜLLERRIED, *1930*, Inst. Biol., Anales, tome 1, no. 2, pp. 165–168, text figs. 1, 2.

About twenty specimens were found, none of which have the upper valve preserved. The animal lived in colonies, the

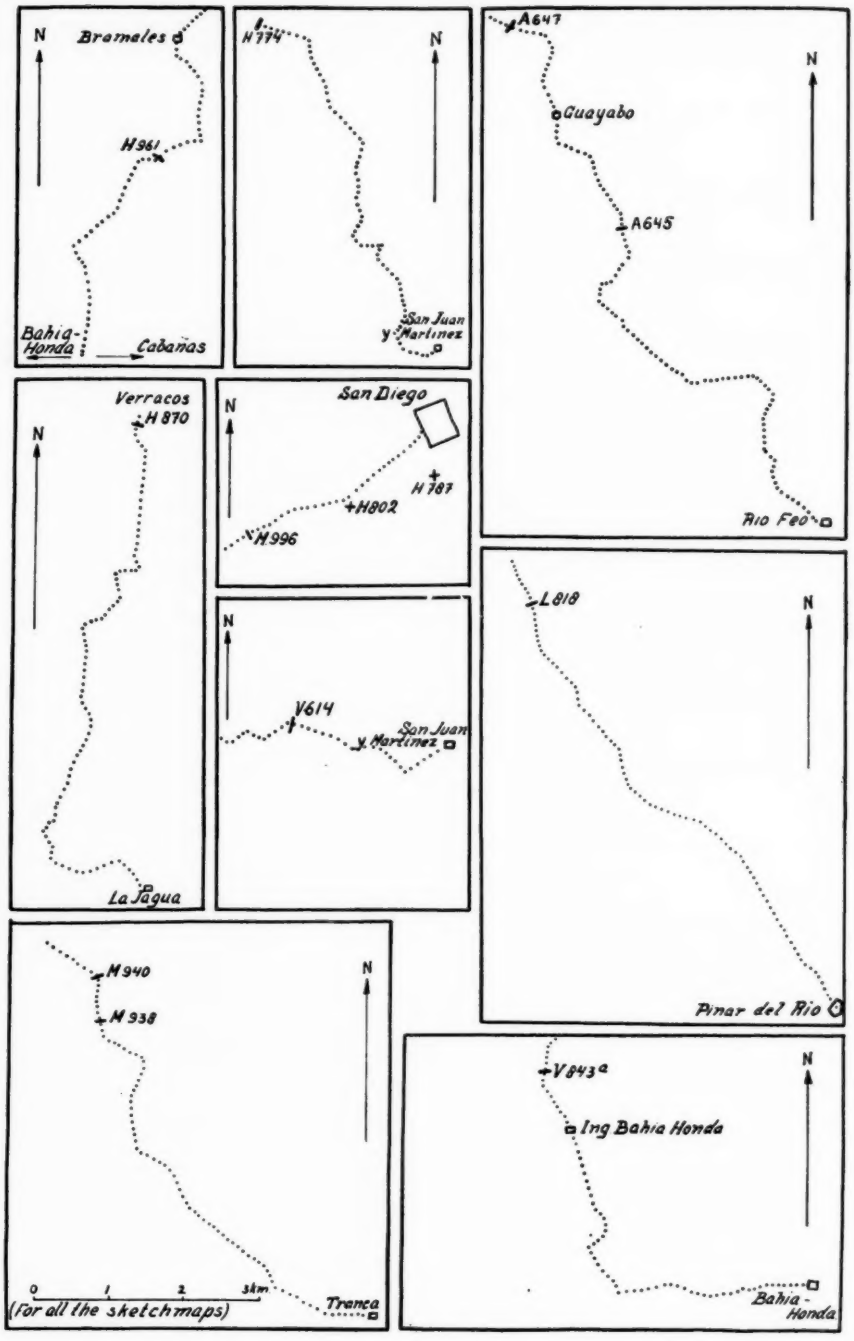

FIG. 1.—Map showing collecting localities.

Distribution of Rudistids in Pinar del Rio Province, Cuba

Localities	A645	A647	H774	H787	H802	H870	H961	L818	M938	M940	M966	V614	V843a
Orbignya müllerriedi Vermunt, n. sp.	—	—	—	—	—	—	—	X	—	—	—	—	—
Orbignya sp.	—	—	X	—	—	—	—	—	—	—	—	—	—
Vaccinites macgillavryi Palmer	—	—	—	X	—	—	—	—	—	—	X	—	—
Vaccinites sp.	—	—	—	—	—	—	X	—	—	—	—	—	—
Pironaea cf. *peruviana* Gerth	—	—	—	—	—	—	—	X	—	—	—	—	—
Barrettia sparcilirata Whitfield	—	—	X	—	—	—	—	—	—	—	—	—	—
Barrettia monilifera Woodward	—	—	—	—	X	X	—	—	—	—	X	—	—
Barrettia multilirata Whitfield	—	—	—	—	X	X	—	—	—	—	—	—	—
Parastroma cf. *guitarti* Palmer	—	—	—	O	—	—	—	—	—	—	—	—	—
Torreites sanchezi (Douvillé)	—	—	—	—	—	X	—	—	—	—	—	—	—
Radiolites sp.	—	—	—	XO	X	—	—	—	—	—	X	—	—
Biradiolites cubensis Douvillé	—	—	—	X	X	—	—	—	—	—	—	—	—
Biradiolites cf. *aquitanicus* Toucas	—	—	—	—	—	X	—	—	X	—	—	—	—
Biradiolites tschoppi Vermunt, n. sp.	—	—	—	—	—	X	—	—	—	—	—	—	—
Biradiolites macgillavryi Vermunt, n. sp.	—	—	—	—	X	—	—	—	—	—	—	—	—
Biradiolites sp.	—	—	X	—	X	—	—	—	—	—	—	—	—
Biradiolites sp.	—	—	—	—	X	—	—	—	—	—	—	—	—
Biradiolites or *Bournonia* sp. indet	—	—	—	—	—	—	—	X	—	—	—	—	—
Bournonia thiadensi Vermunt, n. sp.	—	—	X	—	—	—	—	—	X	—	—	—	—
Bournonia sp.	—	—	X	—	—	—	—	—	—	—	—	—	—
Durania palmeri Vermunt, n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	X
Durania sp.	—	—	—	—	—	—	—	—	—	—	—	—	X
Tampsia rutteni Vermunt, n. sp.	—	—	—	—	—	X	—	—	—	—	—	—	—
Chiapasella pauciplicata Müllerried	—	—	X	—	—	—	—	—	—	—	—	X	—
Chiapasella cubensis Rutten	—	—	—	—	—	X	—	—	—	—	—	—	—
Chiapasella sp. indet	—	—	—	—	—	X	—	—	—	—	—	—	—
Titanosarcolites giganteus Whitfield	X	X	O	—	X	—	—	—	—	X	—	X	—
Plagioptychus sp.	—	—	—	O	—	X	—	—	—	—	—	—	—
Sphaerucaprina sp.	—	—	—	X	—	—	—	—	—	—	—	X	—
Caprinula cf. *annulata* Palmer	—	—	XO	—	—	—	—	—	—	—	—	—	—
Caprinidae	—	—	X	—	—	—	—	—	—	X	—	—	—

largest consisting of seven specimens.

The type specimen is a large form to which two smaller ones are attached. The ligamental crest is broad at the base and rounded at the top. The *S* (letters *S*, *E* and *L*, etc., refer to parts of the shell as illustrated in plates) is short, stumpy, and only very slightly pinched at the base. Length of *S*, 4.5 mm. *E* is larger (7.2 mm.) and pinched at the base. The arc between *L* and *E* is 145 degrees, between *L* and *S*, 70 degrees, and between *S* and *E*, 75 degrees.

Of the cardinal elements, *N* is present and likewise the bordering of tooth alveoles (A_{II}' and P_{II}') (pl. 36, fig. 2), which shows the position of the cardinal apparatus to have been parallel to the circumference. The accessory cavity, therefore, must have been absent or very small.

The maximal thickness of the outer shell layer is 4.5 mm. The inner margin of the outer shell layer is undulated. One undulation is found between *L* and *S* and one between *S* and *E*. In the remaining part there are six undulations, counting the smallest.

The general shape of the shell is cylindrical, with strong broad ribs that are rounded at the surface. These are irregularly shaped and difficult to count, because of the clustered mode of growth of the animals. About ten individuals, according to estimate, may form a single cluster. The grooves are sharp and narrow.

The length of the type specimen

(broken off at both ends) is 105 mm. The diameter is 35 mm. at the top of the lower valve, and about 20 mm. at the lower end.

Other specimens show differences; for example, the ligamental crest is sometimes truncate and in two cases (specimens VII*a* and *b*) the truncate end is slightly impressed, without being clearly bifurcate truncate (pl. 36, fig. 3). The specimens VII*a* and *b* (one colony) also show one undulation of the inner margin of the outer shell layer between *L* and *S* and one between *S* and *E*, but in the remaining part 10 undulations are counted. However, other specimens with a rounded ligamental crest show 7 to 8 undulations in the same part (specimens IV*a* and *b*), thus being intermediate between the type specimen and the specimens VII*a* and *b* in this respect. Specimen I*b* has a large aberrant *L* (text fig. 3*d*).

The *S* in general varies from a broad stump shape to a pinched shape, whereas the *E* is always more or less pinched at the base (text fig. 3*d*).

The mean value of the arc measured on 15 specimens is 145 degrees between *L* and *E*, 70 degrees between *L* and *S*, and 80 degrees between *S* and *E*.

Remarks.—This species is closely related to or identical with specimens described by Müllerried as *Hippurites* cf. *incisus*. There are similar differences between specimens studied by Müllerried and me and forms described in 1895 by Douvillé. Since these differences appear to be constant, it seems proper to create a new species.

Comparison of Orbignya müllerriedi *and* Hippurites resectus *var.* incisus *(Douvillé)*

	O. müllerriedi	*H. resectus* var. *incisus*
Angle between *S* and *E*	145°	120°
Number of ribs	10	15 to 20
Diameter	35 mm.	40 mm.
Ligamental crest	Rounded	Bifurcate truncated

Trechmann, in 1924, described an *Orbignya* sp. from Jamaica, which I take to be identical with the new species.

This species is named in honor of Prof. F. K. G. Müllerried.

Occurrence and types.—Type locality L818. Maestrichtian, Pinar del Rio Province, Cuba. Holotype, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 6, (indicates West Cuba collection, 1933). Hypotypes, W. C. 1933, 1–5, 7–9.

Orbignya sp.

One very small young specimen, imbedded in limestone, was found at locality H774. Its diameter is 12 mm. The

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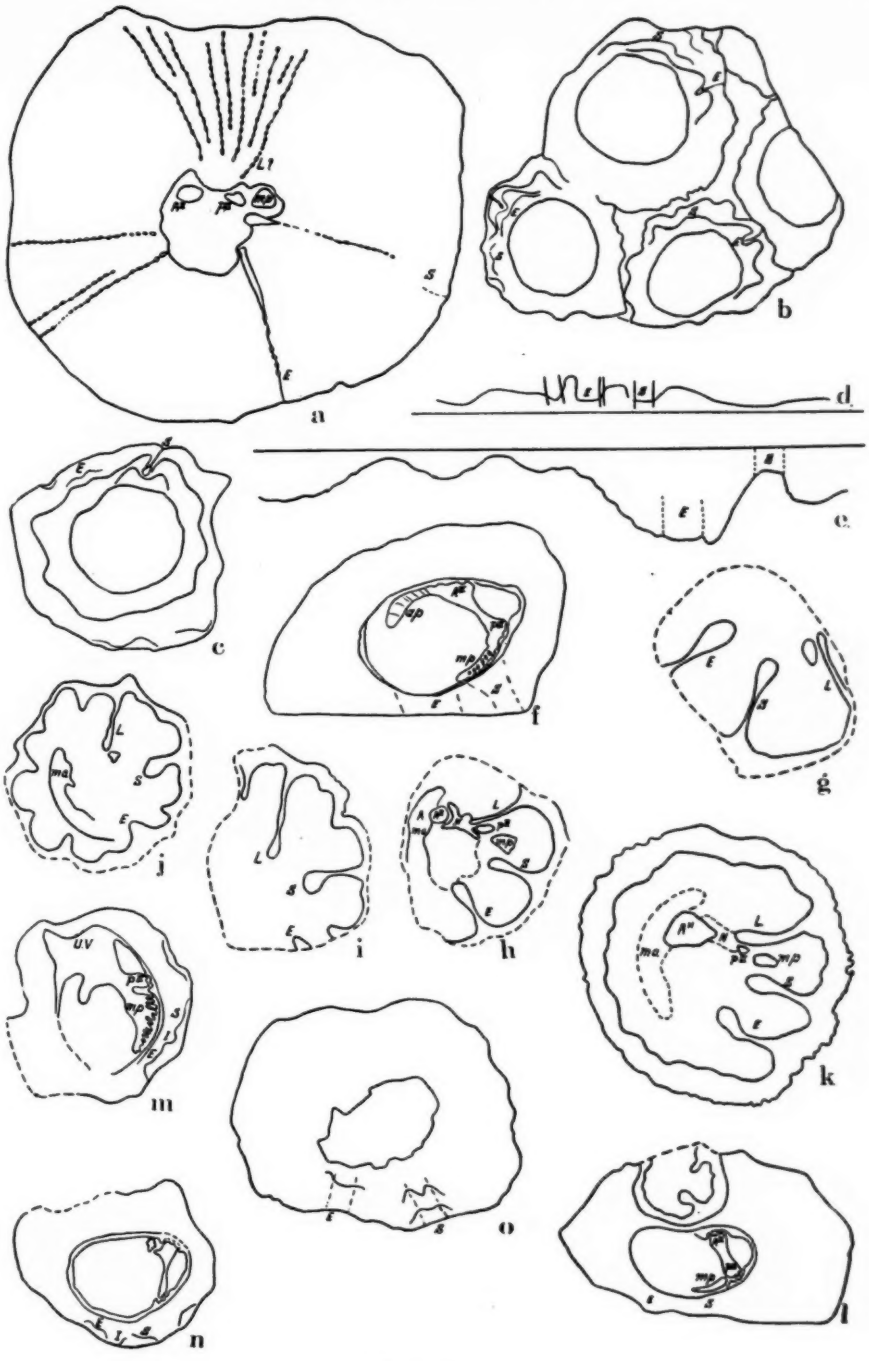
Explanation of Figs 2*a–o*

Fig. 2*a*—*Barrettia multilirata* Whitfield, from Loc. H802, ×0.3. (p. 268)
b, c—*Tampsia rutteni* Vermunt, n. sp. *b*, A colony, the type specimen is at the left bottom, ×0.5. *c*, A high section through the type specimen, ×0.5. (p. 273)
d—Unrolled curve of *Bournonia* sp., the full drawn lines marking the position of the ribs, ×0.5. (p. 272)
e, f—*Biradiolites macgillavryi* Vermunt, n. sp. *e*, Unrolled curve of the type specimen, the dotted lines marking the siphonal zones, ×0.5. *f*, Section of a specimen showing the cardinal apparatus, ×0.5. (p. 270)
g, h—*Vaccinites macgillavryi* Palmer. *g*, Specimen from Loc. M966, ×0.5. *h*, Specimen from Loc. H787, ×0.5. (p. 266)
i, j—*Pironaea* sp. cf. *P. peruviana* Gerth. Two sections through one specimen, section *i* higher than *j*, ×0.5. (p. 266)
k—*Vaccinites* sp., ×0.5. (p. 266)
l—*Biradiolites* sp. from Loc. H774, embracing an *Orbignya*, ×0.5. (p. 271)
m, n—Two sections through one specimen of *Biradiolites* sp. from Loc. H802, section *m* higher up than *n*, showing a part of the upper valve, ×0.5. (p. 271)
o—*Durania palmeri* Vermunt, n. sp. Section through the type specimen, ×0.25. (p. 272)



FIGS. 2*a–o*

L and *S* are developed as slight undulations, the *E* as a somewhat stronger infolding (length 3 mm.), which is broad at the base.

Occurrence.—(?) Maestrichtian, Pinar del Rio province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C. 1933.

Genus VACCINITES Fisher, 1887

VACCINITES MACGILLAVRYI Palmer
Text figures 2*g*, *h*

Vaccinites macgillavry PALMER, *1933*, Rev. Agr., vol. 14, no. 16, fig. 1, pl. 5, figs. 3, 4.

One complete specimen was collected at Loc. H787 and one fragment at Loc. M966. Both show a strong resemblance to *V. macgillavryi*.

The angle between *L* and *E* is 80 degrees. The inclination of the dental apparatus is 40 degrees. Part of the circumference occupied by *L* and *E* (r:u) is 2/7 in the specimen from H787. The ligamental crest is long and thin. The *S* is aberrant in the specimen from M966, being strongly pinched. The *E* is strongly pinched in both specimens (text figs. 2 *g*, *h*). The surface of both specimens is eroded. The shape of the first specimen is conical. Its length with upper valve is 50 mm. The length of the fragment is 65 mm.

Occurrence and types.—(?) Maestrichtian, Pinar del Rio Province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 10–11.

VACCINITES sp.
Text figure 2*k*

One specimen from Loc. H961 is clearly allied to *Vaccinites macgillavryi*. Some differences, however, occur. The inclination of the dental apparatus is 30 degrees. The angle between *L* and *E* is 40 degrees, which is half the angle of *V. macgillavryi*. The part of the circumference occupied by *L* and *E* (r:u) is 1/5. The *L* and *S* are slightly pinched at the base. The *E* is strongly pinched (text-fig. 2*k*). The thickness of the outer-shell layer is 7 to 8 mm. Length with indistinct upper valve, 190 mm.; diameter, 70 mm. The shape is cylindrical. The surface is covered with small costulae, measuring 2 to 3 mm.

Occurrence and types.—(?) Maestrichtian, Pinar del Rio Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C., 1933, 12.

Genus PIRONAEA Meninghini, 1868

PIRONAEA sp. cf. P. PERUVIANA Gerth
Text figures 2*i*, *j*

Pironaea peruviana GERTH, *1928*, Leidsche Geol. Med., Deel 2, pp. 235–237, text-figs. 2, 3.

One specimen of the genus *Pironaea* was found at Loc. L818. The general features of this specimen agree well with Gerth's description.

It differs in the shape of the secondary infoldings of the outer-shell layer. They are shorter than in Gerth's specimen and are broader at the base. In a higher section the secondary infoldings and the *L* and *S* are seen to lengthen (text fig. 2*i*), which strengthens the resemblance with *P. peruviana*. In Gerth's fig. 3 (p. 236) three undulations between *L* and *S* and two between *S* and *E* can be counted. In my specimen two undulations (one of them larger in a higher section) between *L* and *S*, and one slight undulation and

---

EXPLANATION OF FIGS. 3*a–k*

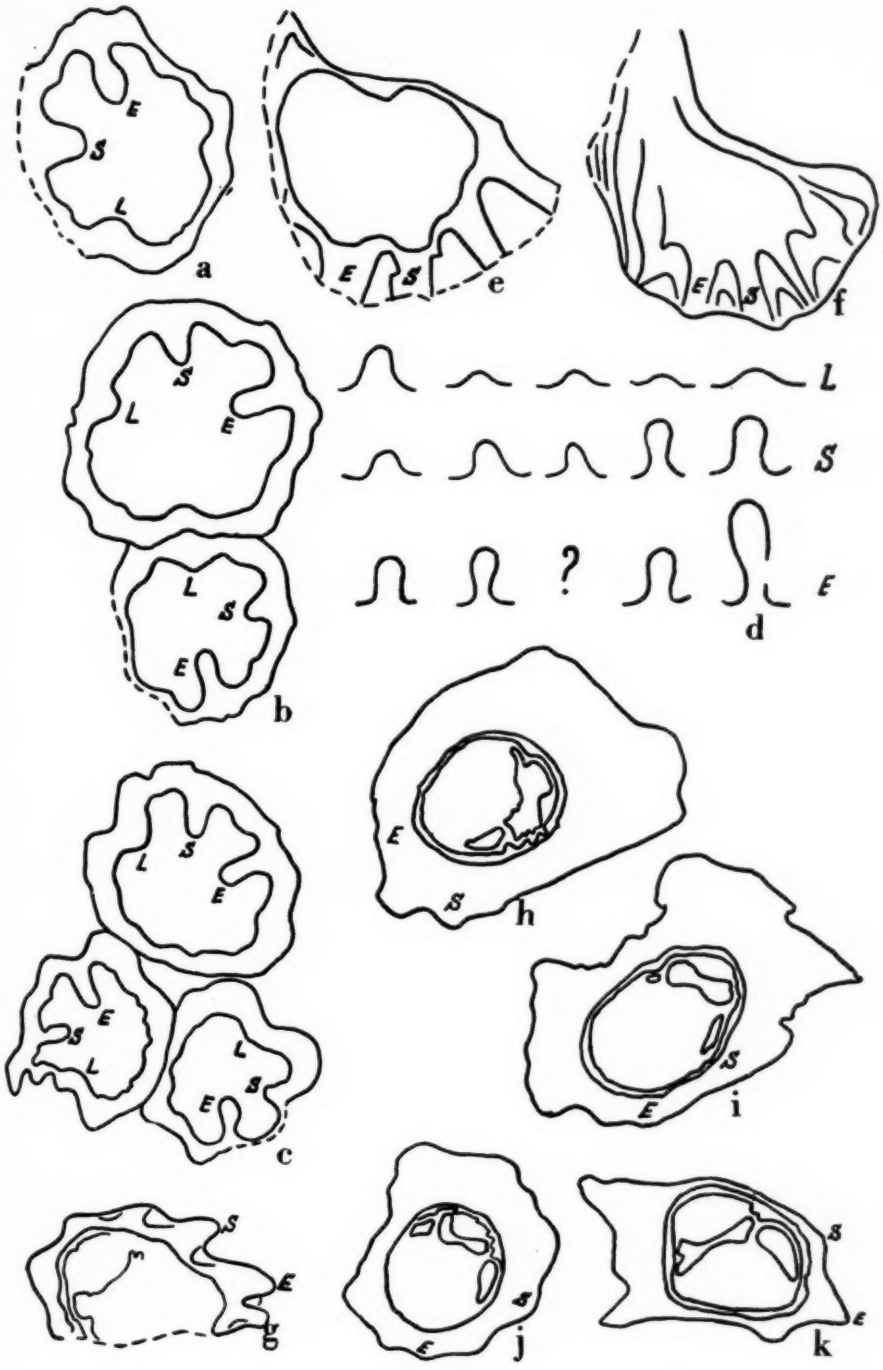
FIGS. 3*a–d*—*Orbignya müllerriedi* Vermunt, n. sp. *a–c*, Type specimen at the upper side of *b*, ×1. *d*, Shape of the *L*, *S* and *E* of those specimens of which no sections are given, ×1. (p. 261)

e–g—*Bournonia thiadensi* Vermunt, n. sp. *e*, Section through the lower valve of the type specimen. *f*, Section through the upper valve of the type specimen. *g*, Section through the specimen from Loc. H774, ×1. (p. 271)

h, *i*—*Biradiolites* sp. from Loc. H774, ×1. (p. 271)

j—*Biradiolites tschoppi* Vermunt, n. sp., ×1. (p. 269)

k—*Bournonia* sp., ×1. (p. 272)



FIGS. 3*a–k*

a secondary infolding between *S* and *E* occur. The shape of *L* is the same but the *L* in Gerth's specimen is curved towards the anterior. The *S* is pinched at the base and knobbed. The *E* in my specimen is scarcely different from a secondary infolding. The number of secondary infoldings is six at the posterior side. The animal grew in two phases: in its youth almost cylindrically for a length of 18 mm. (diameter 22 mm.), suddenly widening out to a diameter of 50 mm., then retaining this diameter for at least a length of 65 mm. The thickness of the outer shell layer is 1 to 3 mm. The surface is finely costulate. Costae and furrows measure 0.5 to 1 mm.

Occurrence and types.—Maestrichtian, Pinar del Rio Province, Cuba. Hypotype, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 13.

Genus BARRETTIA Woodward, 1862

BARRETTIA SPARCILIRATA Whitfield

Barrettia sparcilirata BOISSEVAIN and MACGILLAVRY, *1932*, K. Akad. Wetensch. Amsterdam, Proc., vol. 35, no. 10, pp. 1303–1308, text figs. 1–3.

One incomplete specimen has been found. The species has been carefully described by H. Boissevain and H. J. MacGillavry. Since their material comes from the same locality and does not differ from my specimen, I refer to their publication.

Occurrence and type.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Hypotype, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 14.

BARRETTIA MONILIFERA Woodward

Barrettia monilifera WOODWARD, *1862*, The Geologist, Oct., p. 372, 2 pls.—M. RUTTEN, *1936*, Jour. Paleontology, vol. 10, no. 2, p. *135*.

At two localities material of this species was collected. In the following table, some features of the best-preserved specimens are given.

Measurements of Barretia monilifera

	H802-I	H802-II	H802-III	M966-I	M966-II
Number of moniliform rays	57	60	63	53	36
Diameter in cm.	9–12	12–20	11	9.5	?
Angle between lines drawn through the centers of $A''-P''$ and $P''-mp$.		•		180°	

The body cavity of M966-I and H802-III is excentrical to the anterior side. The shape of the animal is flat conical at the lower end of the lower valve, higher up becoming cylindrical.

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 15–27.

BARRETTIA MULTILIRATA Whitfield

Text figure 2*a*

Barrettia multilirata WHITFIELD, *1897*, Am. Mus. Nat. Hist., Bull., vol. 9, p. 244, pl. 33, fig. 1; pl. 34, fig. 1; pl. 35, fig. 1.—TRECHMANN, *1922*, Geol. Mag., vol. 59, p. 511, pl. 19, fig. 1.

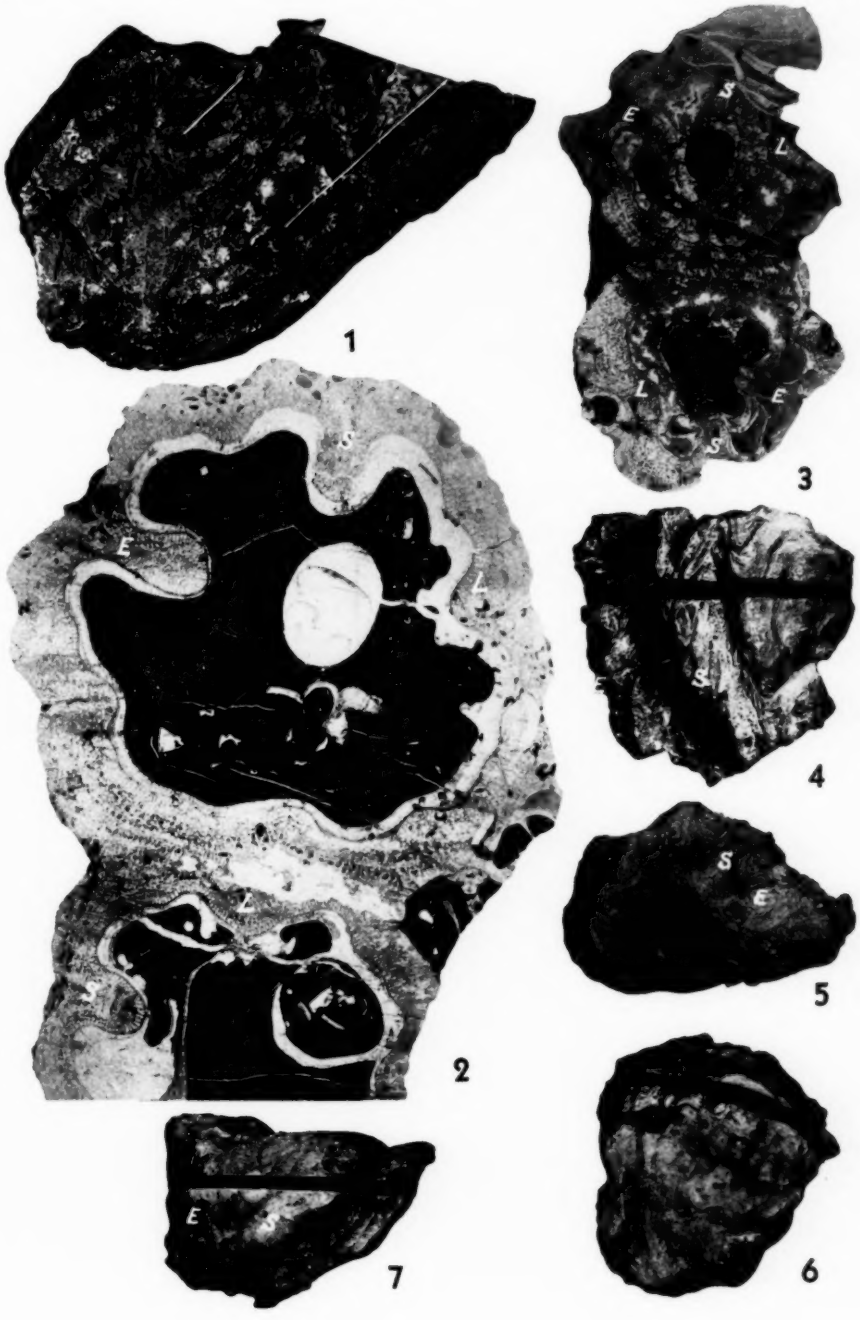
Two specimens collected at Locs. H802 and H870 are believed to belong to this species. They are larger than *B. monilifera*, which does not agree with the earlier descriptions in which *B. multilirata* is said to be more slender than *B. monilif-*

EXPLANATION OF PLATE 36

FIGS. *1–3*—*Orbignya müllerriedi* Vermunt, n. sp. *1*, Surface view of a colony of three specimens showing the posterior side of the type specimen in the middle (white lines separating the three individuals), ×0.6. *2*, Thin-section of the same colony, the largest specimen being the type specimen, ×2.5. *3*, Thin-section of a colony which has an aberrant *L*, ×1.5. (p. 261)

4, 5—*Bournonia thiadensi* Vermunt, n. sp. *4*, From Loc. H774, posterior side, ×1.2. *5*, Upper valve of the same specimen, ×1.25. (p. 271)

6, 7—*Biradiolites tschoppi* Vermunt, n. sp. *6*, Dorsal side, ×1.2. *7*, Same specimen, ×1.6. (p. 269)



Vermunt, Cretaceous Rudistids

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era. The diameter of my specimens is 20 cm., and 20 to 24 cm. About 90 moniliform rays are counted.

The angle between the lines drawn through the centers of A_{II}–P_{II} and P_{II}–mp is 180 degrees in one specimen and 180 degrees or less in the other. Text fig. 2*a* shows the form and the position of *L*, *S* and *E* and the cardinal apparatus. The shape of the smallest specimen is flat conical, with a length of 9 cm. The larger is conical, with a length of 14 cm.

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 28–29.

Genus TORREITES Palmer, 1935

TORREITES SANCHEZI (Douvillé)

Hippurites (*Vaccinites*) *sanchezi* DOUVILLÉ, *1927*, Soc. géol. France, Bull., sér. 4, tome 27, pp. 54, 55, pl. 14, fig. 1.

Torreites sanchezi PALMER, *1933*, Rev. Agr., vol. 14, no. 15, 16, p. 100, pl. 7, figs. 1, 2; pl. 8, figs. 1, 2.—MACGILLAVRY, *1935*, K. Akad. Wetensch. Amsterdam, Proc., vol. 38, no. 5, pp. 563–565.

Two specimens are found at Loc. H870. One is badly preserved, the other shows the *L*, *S* and *E* practically identical in form and position with Palmer's specimen (fig. 2, p. 118). The outer shell layer is not preserved. The shape is cylindrical, length 23 cm., diameter 8 to 11.5 cm.

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 31, 32.

Genus RADIOLITES Lamarck, 1801

RADIOLITES sp.

Several specimens, collected in southern Santa Clara Province, Cuba, will be described by Mr. Thiadens, for he has ample material.

Genus BIRADIOLITES d'Orbigny, 1847

BIRADIOLITES sp. cf. B. AQUITANICUS Toucas

Plate 37, figure 6

Biradiolites aquitanicus TOUCAS, *1909*, Soc. géol. France, Mém., tome 17, p. 107. pl. 20, fig. 20.

Two well-preserved specimens from Loc. H870 and one fragment from M938, are closely allied to this species. They are much larger than the specimen figured by Toucas, for the length of my specimens is 170 mm. and 130 mm.; the dorsoventral diameter is 90 mm. in both specimens, and at right angles to this it is respectively 75 mm. and 80 mm.

The first specimen has a large projection on the A_{II} side, which, though present in the second specimen, is less developed. Ventrally of *E*, there are respectively two and one and a half ribs. Dorsally of *S* there are respectively four and three and a half ribs. The *S*, *E*, and *I* agree with Toucas' specimen. The dorsal cavity is large. The internal features as a whole do not differ from *B. cubensis* as given by Douvillé in 1926. The structure is entirely denticulate. The upper valve is slightly convex.

Occurrence and types.—Maestrichtian, Pinar del Rio Province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 41–43.

BIRADIOLITES TSCHOPPI Vermunt, n. sp.

Plate 36, figures 6, 7; Text figure 3*j*

Lower valve.—This species is very small and characterized by a large number of small ribs, about 16 occurring on the dorsal side. The ribs and grooves measure about 2 mm. A group of about seven smaller ones are found dorsally of the posterior siphonal band. Together they form a sort of larger rib, 6 mm. in width. Three downward folds occur in the siphonal region, limiting the *S* and *E* which measure about 5 mm. at the top of the lower valve. The *I* is narrow and asymmetrical. From *E* towards *S*, the funnel plates slope downward only very slightly at first, then rise steeply. The anterior fold is best developed. At the dorsal side small upward undulations correspond with the ribs.

The maximum thickness of the outer shell layer at the dorsal side is 7 mm. The minimum thickness at the anterior side is 2 mm.

The cardinal apparatus is shown in text fig. 3*j*.

The prismatic cells are radially arranged. Some of the prismatic cell walls are reduced to a series of vermiculations, running parallel to the next ones.

The animal probably lived unattached. It shows a slight torque to the right, looking from the apex of the valve in the direction of the upper brim.

Upper valve.—The upper valve is only partly preserved. It probably covers the whole lower valve and is slightly concave or flat. The apex is found subcentrally. The diameter of the whole valve is 20 to 25 mm.; the length is 25 mm. (broken off).

Remarks.—The characters by which the new species differ from known forms of *Biradiolites* are the small ribs at the dorsal side, the asymmetrical "interbande" rib, and the composite rib dorsally of the *S*.

This species is named in honor of Doctor Tschopp.

Occurrence and types.—Type locality H870. (?) Maestrichtian, Pinar del Rio Province, Cuba. Holotype, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 44.

Biradiolites macgillavryi Vermunt, n. sp.

Plate 37, figure 3; Text figures 2*e*, *f*

One cluster of five specimens was found, one of which, selected as the type, shows both siphonal areas. Only the lower valve is preserved.

The maximum thickness of the outer shell layer is 30 mm.; the minimum thickness is 8 mm. at the posterior side. The structure of the prismatic cells is very fine and irregularly vermicular to polygonal.

Of the outer surface only the posterior side and the ventral side are visible. The posterior side shows the posterior siphonal band to consist of a very sharp upfold measuring 6 mm. at the top of the lower valve. The funnel plates bend sharply downward (*I*), only to turn up very slightly again towards *E*, which is 10 mm. broad and marked by the regularity of the funnel plates. At its anterior limit the funnel plates suddenly rise again, showing slight undulations. At the ventral side we find three large, flat folds that also show minor undulations (text fig. 2*e*).

The thickness of the inner shell layer is 0.5 mm.

The shape of the animal is elongated conical, in places irregular, caused by its growing in clusters. The diameter of the top of the lower valve is 85 mm.; the length of the incomplete specimen is 55 mm.

One specimen shows the cardinal apparatus, with A_{II} and P_{II} connected. The anterior and the posterior myophore are septated. The anterior side is flat without ribs, showing only broad and slight undulations of the funnel plates which are closely packed and 0.07 to 0.1 mm. in thickness. The "limbe" is undulated and without vessel impressions.

This species is named in honor of Mr. H. J. MacGillavry.

Occurrence and types.—Type locality H802 (?) Maestrichtian, Pinar del Rio Province, Cuba. Holotype, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 45.

Explanation of Plate 37

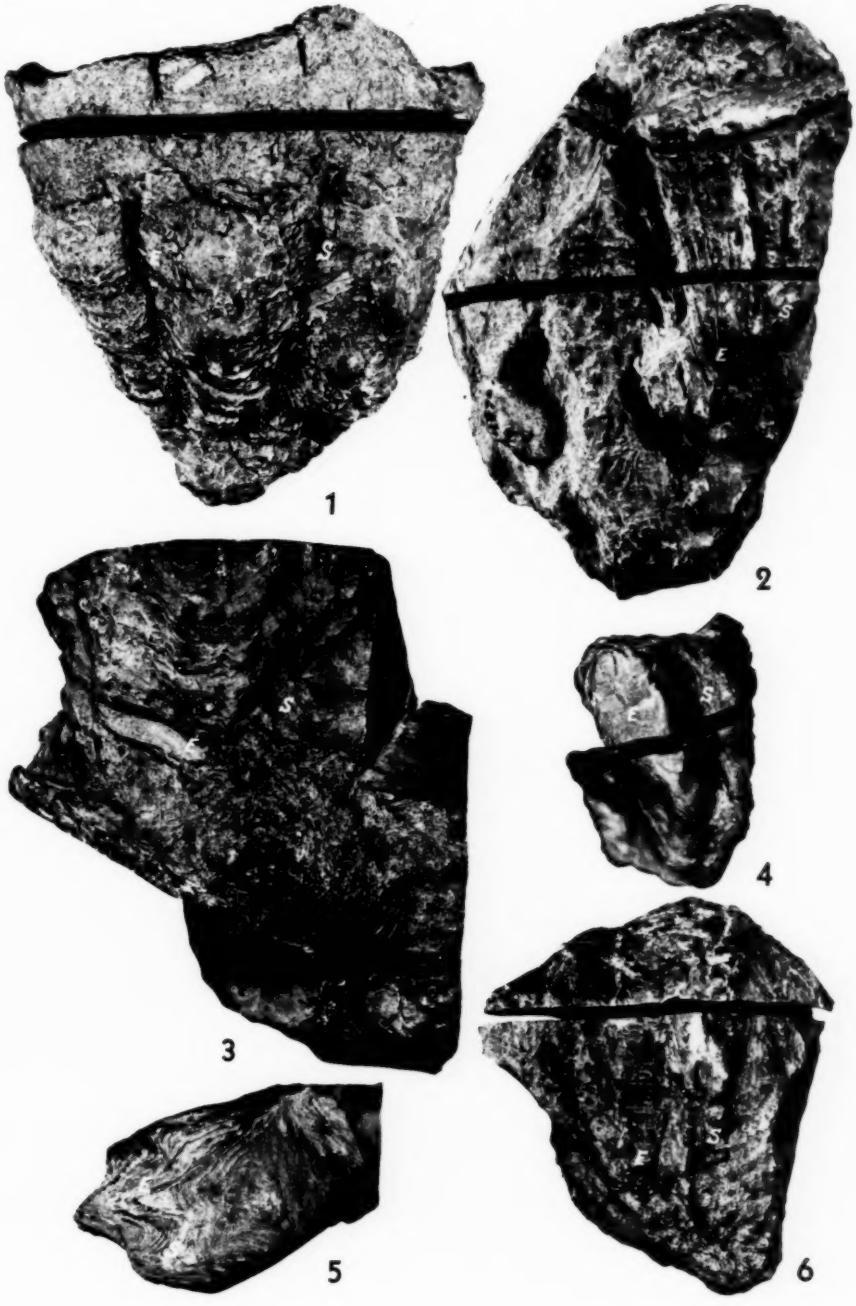
Fig. *1*—*Durania palmeri* Vermunt, n. sp. Posterior side of the type specimen, ×0.42. (p. 272)

2—*Tampsia rutteni* Vermunt, n. sp. Posterior side of the type specimen, showing the typical fold near *E*, because of erosion, ×0.55. (p. 273)

3—*Biradiolites macgillavryi* Vermunt, n. sp. Posterior side of the type specimen, ×0.62. (p. 270)

4, *5*—*Bournonia* sp. *4*, Posterior side, ×1.25. *5*, Upper valve of same specimen, ×0.8. (p. 272)

6—*Biradiolites* sp. cf. *B. aquitanicus* Toucas. Posterior side of the second specimen from Loc. H870, ×0.33. (p. 269)



Vermunt, Cretaceous Rudistids

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BIRADIOLITES sp.

Text figures 2*l*, *m*, *n*; 3*h*, *i*

Lower valve.—There are three downward folds, two of which limit the siphonal bands, the third (interbande) occurring between them, separated from them by a slight groove. The *S* and *E* measure, at the top of the lower valve, respectively 3 to 3.5 mm. and 6 mm. In one specimen it appears that *E* is ribbed, but because of weathering of the shell I am not sure of it. The extremely thin funnel plates show slight and irregular, or in some cases regular, undulations (2 to 3 mm. to the undulation). The features of the cardinal apparatus are shown in text figs. 2 *l*, *m*, *n* and 3 *h*, *i*.

One specimen shows the anterior myophore to be septate. The same holds true for the posterior myophore, as is shown in text fig. 2 *m*, and in a higher section of the specimen seen in text-fig. 3*h*. Apparently the septation occurs mostly in the higher parts of the myophores.

The accessory dorsal cavity is somewhat variable but mostly rather small. The thickness of the outer shell layer is greatest slightly posterior of the dorsal side in most specimens (26 mm. in specimen shown in text fig. 3*h*). Minimal thickness mostly at the posterior side (5 mm.).

Upper valve.—Probably the upper valve does not cover the lower entirely. The shape is slightly convex to flat with a sub-central apex.

Cell structure.—The prismatic cell structure is well shown only in the specimens seen in text figs. 2*m*, *n* and 3*h*. In some shells (text fig. 2*m*, *n*) the cells are long and slender and radially arranged at the anterior and dorsal side. Posteriorly and ventrally they are irregular. At the ventral side, part of the cell walls have disappeared, leaving parts of them as tiny white spots. In the specimens shown in text-fig. 2*l*, practically the entire structure consists of these white spots.

The animal grew in clusters, adhering closely to specimens of its kind or other rudistids (*Chiapasella* and *Orbignya*). The *Orbignya* has been almost entirely embraced by the specimen seen in text fig. 2*l*. The anterior side is flattened to concave.

The animal is probably related to Jamaican forms.

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 46–51.

BIRADIOLITES sp.

Among specimens that cannot be specifically identified there is one form that is of paleontological interest. It is a flat and widely spread, large *Biradiolites* with an extremely fine structure, irregularly denticulate. The siphonal zones are very narrow (9 to 13 mm.).

The animal is interesting because of its size and its *Sphaerulites*-like appearance. It measures 245 mm. dorso-ventrally and 225 mm. at right angles to it. Its height is 90 mm. or somewhat more, since the specimen is eroded.

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 52.

Genus BOURNONIA Fisher, 1877

BOURNONIA THIADENSI Vermunt, n. sp.

Plate 36, figures 4, 5; Text figures 3*e*, *f*, *g*

Bournonia sp., M. RUTTEN, *1936*, Jour. Paleontology, vol. 10, no. 2, p. 138, text fig. 4*k*.

Two specimens of this species were found in western Cuba, at Locs. H774 and M938. One of them, attached to another rudistid, was taken as type specimen. *Bournonia* sp. Rutten, described from northern Santa Clara Province, Cuba, agrees well with my specimens.

Lower valve.—The posterior and anterior siphonal bands are pronounced ribs (downfolds of the funnel plates), 4 to 6 mm. in breadth. They are separated by a sharp groove. Dorsally of the *S*, there are two sharp ribs, and ventrally of *E* is another one which is indistinct in the section through the lower valve of

the type specimen because of erosion, but clearly visible in the section through the specimen from Loc. H774 (text fig. 3*g*) and in the section through the upper valve of the type specimen (text fig. 3*f*).

The anterior side is flat. In the specimen figured by Rutten, slight undulations, caused by its growth upon the ribs of *Chiapasella*, occur in this region. On the anterior-ventral side of the type specimen another fold occurs which embraces another rudistid, to which the *Bournonia* adheres with its anterior side. The accessory dorsal body cavity is rather large. The body cavity widens out strongly into the *S* and *E* ribs, less into the other ones.

The internal features are clearly shown in the figure of Rutten's specimen.

Upper valve.—The upper valve is best preserved in the specimen from Loc. H774. It entirely covers the lower valve, is slightly depressed, with the apex anterior to the center and somewhat raised. At the border of the upper valve the ribs correspond to the grooves of the lower valve. The *S* and *E* are developed as grooves.

The length of the type specimen is 47 mm.; the diameter dorso-ventrally is 37 mm., and antero-posteriorly 25 mm.

In horizontal section the structure appears to be denticulate, which recalls *Parabournonia hispida*. Our form also has in common with this species the presence of ribs, but it differs in having a much larger accessory dorsal cavity and by the irregular contours of the body cavity.

The upper valve shows the same funnel plate structure, with only a few denticulations here and there.

This specimen is named in honor of Mr. A. A. Thiadens.

Occurrence and types.—Type locality M938. Maestrichtian, Pinar del Rio Province, Cuba. Holotype, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 53. Hypotype, *idem*, W. C. 1933, 54.

BOURNONIA sp.

Plate 37, figures 4, 5; Text figures 2*d*, 3*k*

Lower valve.—A typical *Bournonia*, growing with its antero-dorsal side upon a caprinid. Three distinct ribs occur. The *S* is developed as a 4 mm.-broad, flat-bottomed downward fold. The *E* is a 5 mm.-broad, flat-bottomed downward fold, which occupies the ventral side of a sharp rib, which is separated from S by a narrow groove. Ventrally of *E* a sharp-bottomed downward fold appears with growth, making the third rib. The antero-ventral face is flat.

The internal features are shown in text-figure 3*k*.

The accessory dorsal cavity is large. The body cavity widens out slightly towards the *E* and *S* and the ventral fold.

Upper valve.—The upper valve is slightly depressed in the center, covering the lower valve entirely. At the border it is somewhat elevated between *S* and *E*, and *V* and *S*, and more strongly elevated at the ventral and dorsal side.

In a horizontal section a cell structure of discontinuous more or less radial cell walls is seen. The diameter through the siphonal zones is 30 mm., and 17 mm. at right angles to this. The length is 30 mm.

Remarks.—In the position of *E* on the anterior face of the second rib, our form is clearly related to *B. gardonica*, *B. fourtaui* and *B. lecocqi*. It differs from them all by its squat shape. Moreover, these species are insufficiently delimited so that it is impossible to name this form specifically.

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 55.

Genus DURANIA Douvillé, 1908

DURANIA PALMERI Vermunt, n. sp.

Plate 37, figure 1; Text figure 2*o*

A large number of specimens representing this species were collected. They are poorly preserved, however, for of some 20 specimens only one shows both siphonal zones distinctly. This specimen has been selected as the type. Only the lower valve is preserved.

The outer shell layer consists of irregularly arranged polygonal cells of variable size. The diameter of the largest cells is 0.6 mm. The maximal thickness of the outer shell layer is at the antero-ventral side (60 mm.); the minimal thickness is at the posterior side (25 mm.).

The inner shell layer is poorly preserved, the body cavity being strongly crushed and broken. The thickness of a fragment of the inner shell layer is 0.75 mm.

The outer surface is covered with small ribs representing downfolds of the funnel plates. They measure 3.5 mm. to 5 mm.

The anterior and posterior siphonal zones are broad shallow grooves (upfoldings). The siphonal bands are poorly preserved in places, but they show undulations smaller (2.5 mm.) than those on the outer surface. The siphonal bands are clearly indicated on a polished section at the top of the lower valve, where they measure about 11 mm. The interbande is a large downfold bearing the same surface ornamentation of small ribs. The growth-layers are imbricating.

None of the internal features are preserved.

The type specimen lived unattached. It has a large conical form, slightly concave at the anterior side. Length of the valve 180 mm.; diameter dorso-ventral 150 mm., antero-posterior 120 mm.

Other specimens which we refer to this species are slightly different, part of them being more elongated conical to cylindrical in form.

The posterior siphonal band is found "*a fleur du test*" (anterior one not found).

A radial section through a conical form and a more cylindrical one shows the same inclination of the funnel plates towards the axis of the shell. The angle of the funnel plates in both specimens is about 80 degrees at the lower end of the lower valve, and about 70 degrees at the middle and top of the lower valve. The thickness of the funnel plates is 0.15 mm. to 0.5 mm. in the conical specimen and 0.5 mm. in the cylindrical one.

In both specimens the largest prismatic cells measure 0.6 mm., in agreement with the type specimen. The conical and the elongated conical to cylindrical forms are found living in colonies as well as unattached.

The species has been named in honor of Mr. R. H. Palmer.

Occurrence and types.—Type locality V843a. (?) Maestrichtian, Pinar del Rio Province, Cuba. Holotype, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 84. Hypotypes, *idem*, W. C. 1933, 85–101.

Durania sp. A and B

Three fragments were found at the same locality as *D. palmeri*.

The prismatic cells are distinctly larger than in *D. palmeri*, the diameter of the largest being 1.5 mm. Two of the fragments have sharply folded funnel plates, while one of these shows small ribs (down foldings of the funnel plates in its outer surface) which are subdivided by a small groove. The ribs measure up to 6.5 mm. The specimen without folded funnel plates (sp. B) grows together with *D. palmeri* in one cluster.

Occurrence and types.—(?) Maestrichtian, Pinar del Rio Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 102–104.

Genus Tampsia Stephenson, 1922

Tampsia rutteni Vermunt, n. sp.

Plate 37, figure 2; Text figures 2*b*, *c*

One colony consisting of five individuals was found. Two of them are fragments, but of the other three the lower valve is more or less completely preserved. A section shows the typical features of the genus *Tampsia*.

The *E* is developed as a narrow folding completely closed at the periphery of the outer shell, where it is marked by a narrow slit. This folding projects about 8 mm. into the interior of the outer shell. The funnel plates, which are undulated (corresponding to the ribs at the periphery of the outer shell), behave close to *E* just as those of Stephenson's species.

The posterior siphonal zone is, however, differently developed from that of the known species, *T bishopi* and *T chocoyensis*. The *S* in *T. bishopi* is a "broad deeply excavated posterior" channel, in *T. chocoyensis* it "is very shallow and in others is broken into a main and subordinate channel by an intermediate rib." In *T. rutteni*, type specimen, the *S* is a broad rib (downfold) measuring 13 mm. at the top of the lower valve, which is subdivided by a slight groove. The slit *E* is bordered at the dorsal and ventral side by an equally subdivided rib, measuring respectively 10 mm. and 8 mm. at the top of the lower valve. The *S* is bordered by two grooves (upfolds), the dorsal one measuring 5 mm. and the ventral one 3 mm.

Two ribs (downfolds) are visible at the dorsal side, they are undivided and measure 10 mm. and 7 mm. The other ribs, possibly 4 or 5, are badly preserved, owing to the eroded surface, or invisible through the attachment of other individuals to the type specimen.

The surface of the outer shell shows in places fine longitudinal striations (0.3 mm. to 0.45 apart).

The inner shell layer is very thin, 0.5 mm.

The prismatic cells of the outer shell layer are slightly radially arranged and polygonal and irregular in horizontal section. Towards the middle, where the funnel plates are intersected at a much greater angle (more closely packed in horizontal section), this radial arrangement becomes much more marked. At the periphery, at least on the siphonal area of the type specimen, there is a broad zone of compact lamellose cortex structure. It is here that we have proof of striations on the outer surface. In one specimen there is even a non-lamellose compact cortex.

The body cavity has a more or less circular section, but its margin is flattened or even curved inwards at the siphonal areas.

The shape of the animal is elongated conical. The type specimen, which is the largest, measures: length 110 mm.; diameter at the top of the valve 60 mm.; diameter of the body cavity at the top of the valve 30 mm.

This species is named in honor of Prof. L. M. R. Rutten.

Occurrence and types.—Type locality H870. (?) Maestrichtian, Pinar del Rio Province, Cuba. Holotype, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 105.

Genus CHIAPASELLA Müllerried, 1931

CHIAPASELLA PAUCIPLICATA Müllerried

Chiapasella pauciplicata MÜLLERRIED, *1931*, Inst. Biol., Anales, tome 2, no. 3,
Chiapasella radiolitiformis BOISSEVAIN and MACGILLAVRY, *1932*, K. Akad. Wetensch. Amsterdam, Proc., vol. 35, no. 10, pp. 1308–1312, text figs. 4–6.

Several specimens collected at Loc. H774 and two at Loc. V614 agree well with Müllerried's description of *C. pauciplicata*. There are seven to eight larger infoldings of the cortex layer in the outer shell layer and a few (one to two) smaller ones.

A revision of Boissevain and MacGillavry's material, which was collected at practically the same locality (H774), shows that their specimens are not intermediate between *C. pauciplicata* and *C. radiolitiformis*, as stated by the authors, but identical with *C. pauciplicata*, so that their argument for suppressing this species is invalid. In their best preserved specimen we counted nine larger infoldings and four short ones.

The siphonal bands are placed on ribs, as already stated by Müllerried and M. Rutten.

The canals of the upper valve agree in number and shape entirely with Boissevain and MacGillavry's fig. 4, thus being different from Müllerried's description (fig. 12).

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 75–83.

Genus PLAGIOPTYCHUS Matheron, 1842

(?)PLAGIOPTYCHUS sp.

At San Diego one fragment was found

that probably is the upper valve of a *Plagioptychus*. It has typical pyriform canals, the septa between them bifurcating twice. Part of the outer shell layer is preserved.

Another fragment from Loc. H870 shows pyriform canals and thrice bifurcating septa.

Occurrence and type.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 66–68.

Genus SPHAERUCAPRINA Gemmellaro, 1865

SPHAERUCAPRINA sp.

A very small individual collected at Loc. V614 undoubtedly belongs to either *Sphaerucaprina* or *Mitrocaprina*, as indicated by absence of canals in the lower valve and presence of polygonal and radial canals in the upper valve. The presence of a ligamental cavity could not be ascertained nor that of irregular dorsal cavities. Taking everything into consideration, it seems more probably to belong to *Sphaerucaprina*.

The specimen measures about 30 mm. dorso-ventrally and 43 mm. proximo-distally. Its height is about 25 mm. The upper valve is very flat.

Another specimen, found at Loc. H787, agrees with the former and completes the observations.

The ligamental inflexion, as well as a few irregular cavities dorsal of *ma*, are seen. The nature of the canals is better visible in this specimen. There is a single row of polygonal canals, frequently interrupted ventrally by larger pyriform marginal canals, but nearly continuous at the posterior side. Ventrally of the septum two or three more polygonal canals are wedged in between this row and the marginal canals and likewise one at the anterior side.

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 69, 70.

Genus CAPRINULA d'Orbigny, 1847

CAPRINULA sp. cf. C. ANNULATA Palmer

Caprinula annulata PALMER, *1933*, Rev. Agr., vol. 14, nos. 15, 16, pp. 102, 103, pl. 9, figs. 1–3.

Two poorly preserved specimens may belong to Palmer's species.

Occurrence and types.—(?)Maestrichtian, Pinar del Rio Province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 71, 72.

Family CAPRINIDAE Fisher, 1887

One indeterminable fragment of a caprinid, grown upon by a *Bournonia* sp., has marginal and many polygonal canals (about triple series) in the inner shell layer, and fibrous outer shell layer.

Another caprinid fragment at M940 has multiple polygonal canals interior to the marginal ones. Generic determination cannot be made.

Occurrence and types.—Maestrichtian, Pinar del Rio Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, W. C. 1933, 55, 73.

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L. W. J. VERMUNT, MINERALOGICAL-GEOLOGICAL INSTITUTE, UTRECHT UNIVERSITY, UTRECHT, HOLLAND. MANUSCRIPT RECEIVED BY THE EDITOR, MAY 10, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 4, PP. 276–288, PLS. 38–40,
TEXT FIGS. 1, 2, JUNE, 1937

PENNSYLVANIAN OSTRACODA FROM SULLIVAN COUNTY, INDIANA

KENNETH ARMSTRONG PAYNE

ABSTRACT

Twenty-five species (12 new) and varieties (3 new) of Pennsylvanian ostracodes from Sullivan County, Indiana, are described and figured. The fauna occurs in a shale seam one inch thick in the Hayden Branch formation, upper Pennsylvanian, probably upper Conemaugh in age. Two new stratigraphic names, the Murphys Bluff sandstone and the Hayden Branch formation, are proposed by C. A. Malott. Correction of stratigraphic identification of the Ashmore Creek section in Clark County, Illinois, is made.

INTRODUCTION

The first rock formation to be named in Indiana was the Merom sandstone (John Collett, 1871). A few years ago Prof. C. A. Malott of Indiana University began a detailed study of the Merom sandstone and its associated formations. From beds, now designated as the Hayden Branch formation, that occur about 110 feet below the Merom, he and M. M. Fidlar of Indiana University collected many fossils. This paper, which is the first attempt to describe and figure Pennsylvanian ostracodes from Indiana, is devoted to specimens from the Hayden Branch formation.

Acknowledgments.—I express deep appreciation to Professor Malott for aid with regard to the stratigraphy, and to Prof. J. J. Galloway of Indiana University for valuable suggestions and criticisms in completing the research and for reading the manuscript.

LOCATION

The ostracodes here described were found in a layer of soft gray shale only 1 inch thick in the Hayden Branch formation. The locality is in the north-central portion of sec. 10, T. 8 N., R. 10 W., in Turman Township, Sullivan County, Indiana. The formation outcrops in the bed of Hayden Branch, about 100 yards south of the section-line road. The section-line road crosses Hayden Branch about three-fourths of a mile east of the town of Dodds Bridge. Hayden Branch runs northward and empties into Turmans Creek which flows in a southwest direction and empties into the Wabash River about 3 miles north of the town of Merom.

STRATIGRAPHY

The Pennsylvanian sediments in the vicinity of Dodds Bridge in Sullivan County, Indiana, are upper Pennsylvanian and probably upper Conemaugh in age. Up to the present time the Merom sandstone has been the only formation recognized and named from this region. Besides the Merom, Professor Malott has recognized two formations in this area, for which he has given the names Murphys Bluff sandstone and Hayden Branch formation in his field notes, and which he here describes.

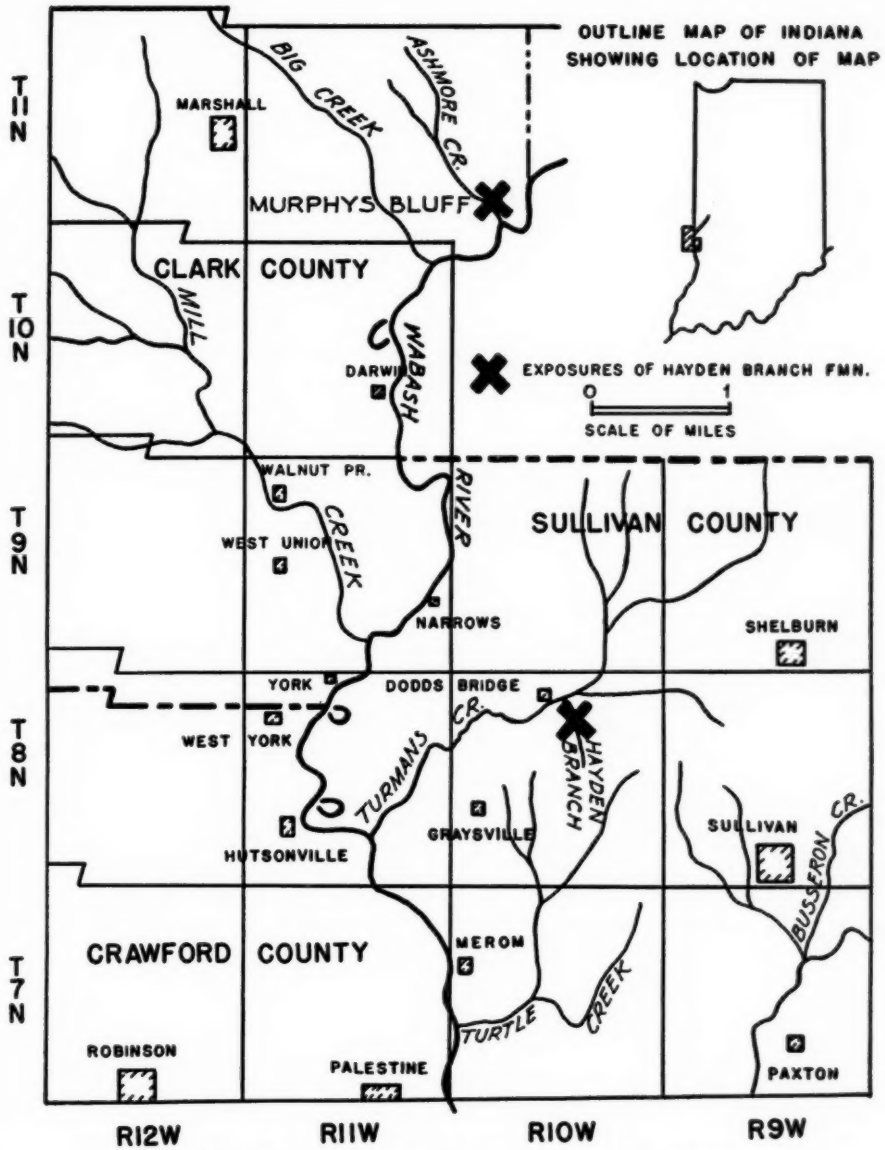

FIG. 1.—Map of portions of Sullivan County, Indiana, and Clark and Crawford counties, Illinois.

MURPHYS BLUFF AND HAYDEN BRANCH FORMATIONS

By C. A. Malott

The type locality of the Murphys Bluff sandstone is at Murphys Bluff, along Ashmore Creek in Clark County, Illinois, where it is a massive sandstone 60 feet in thickness. The Illinois Geological Survey identifies this sandstone as Merom, the type locality of which is at Merom, in Sullivan County, Indiana. The relation of the sandstone in the

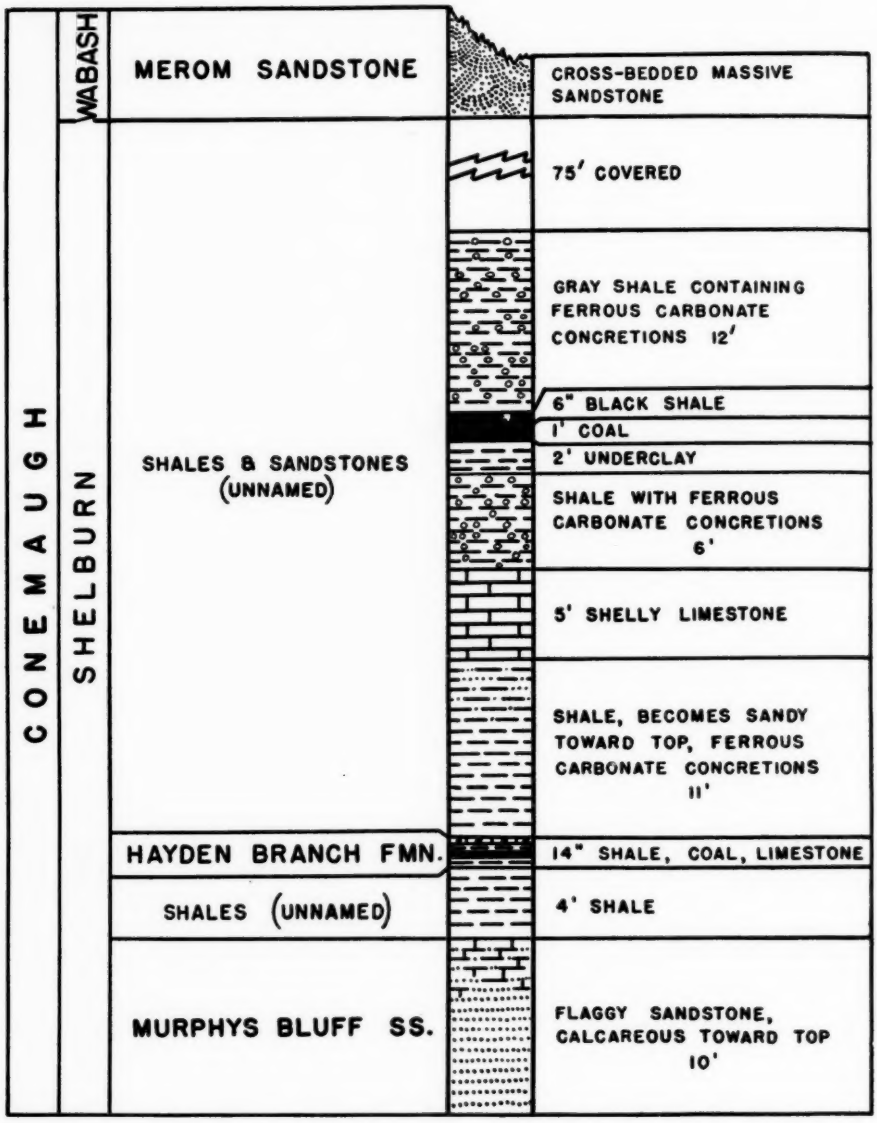

FIG. 2.—Pennsylvanian section near Dodds Bridge in Sullivan County, Indiana.

Ashmore Creek section in Illinois to the overlying Hayden Branch formation and to the section in the vicinity of Dodds Bridge in Indiana, 16 miles to the southeast, seems to show that the sandstone is below the true Merom which is not present in the Ashmore Creek section.

Exposures of rocks in the Dodds Bridge locality include small thicknesses of strata, but a composite of several exposures may be secured which, pieced together, make 100 feet or more of section which include the Hayden Branch formation and the Merom sandstone.

The Murphys Bluff formation is the lowest formation outcropping in this region. It consists of 10 feet of flaggy sandstones which

become somewhat calcareous in the upper part. This sandstone is separated from the Hayden Branch formation by 4 feet of soft gray shale.

The Hayden Branch formation, at the type locality in the bed of Hayden Branch, includes 6 inches of underclay, 1 inch of coal, 1 inch of very fossiliferous soft gray shale containing the ostracodes described below, and 6 inches of dark fossiliferous limestone with many black phosphatic concretions which weather white. This formation has an elevation of 480 feet in this region. It is covered with mud most of the year, being exposed only during the spring rains.

The Hayden Branch formation is overlain by 11 feet of shale which becomes sandy toward the top and contains layers of ferrous carbonate concretions. This is followed by 5 feet of shelly limestone and 6 feet of gray shale with layers of ferrous carbonate concretions. This is overlain by 2 feet of dark underclay, followed by 1 foot of coal, which is mined locally as the Dodds Bridge coal. The coal is overlain by 6 inches of black shale which is nearly sheety in appearance. This is followed by 12 feet of gray shale containing ferrous carbonate concretions in layers. Approximately 80 feet of the section between the shale and the Merom sandstone is covered and its lithology unknown. Up the creek some three-fourths of a mile south of the Hayden Branch formation outcrop, are limited exposures of sandstone and finally the base of the Merom sandstone. The latter is probably 100 feet or a little more above the Hayden Branch formation.

The Merom sandstone, which has an elevation of 590 feet in this region, is a coarse soft cross-bedded and massive sandstone. It is one of the most conspicuous sandstones in Indiana.

FAUNA

Twenty-five species and varieties of ostracodes of the families Leperditellidae, Kirkbyidae, Bairdiidae, and Cytherellidae are described and figured. Twelve of the species are new; there are three new varieties.

Orientation is very important when making identifications. The thicker end is here considered to be posterior.

The fauna, which has not been studied in detail, contains, in addition to Ostracoda, the following groups:

Protozoa: *Endothyra*, *Schubertella*
Porifera: Sponge spicules
Corals: *Lophophyllum*
Echinodermata: Crinoid segments and plates
Bryozoa: *Rhombopora*, *Fenestella*, *Polypora*, *Pinnatopora*
Brachiopoda: *Composita*, productids
Pelecypoda: *Nucula*, *Edmondia*
Gastropoda: *Orestes*, *Euomphalus*
Scaphopoda: *Plagioglypta*
Conodonta: *Idiognathodus*
Fish teeth

The fossils are all small. The corals, crinoids, brachiopods, mollusks and fish teeth appear to be dwarfed.

SYSTEMATIC DESCRIPTIONS

Family LEPERDITELLIDAE Ulrich and Bassler, 1906

Genus ANTIPARAPARCHITES Coryell and Rogatz, 1932

ANTIPARAPARCHITES WABASHENSIS Payne, n. sp.

Plate 38, figures 1*a*, *b*

Carapace small, leperditoid in lateral view, with forward swing; valves unequal, the left overlapping the right along free border; greatest length near the median line, greatest height slightly anterior to center; greatest thickness one-third length from posterior end; dorsal margin straight; ventral margin convex, curving upward evenly into the broadly rounded ends; hinge line depressed below the dorsal regions of the valves; overlap well developed on ventral margin, narrowing considerably at the ends; a slightly depressed spot ap-

pears on the right valve at the point of greatest thickness, another spot appears on the left valve slightly more to the posterior. Length, 0.43 mm.; height, 0.28 mm.; thickness, 0.29 mm. Form ratio, 1.53. Very rare.

Remarks.—The overlap is much greater along the ventral margin of this form than that of *A. reversus*. The two spots are also a distinguishing feature of this species.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3203.

Family KIRKBYIDAE Ulrich and Bassler, 1923

Genus AMPHISSITES Girty, 1910

AMPHISSITES CENTRONOTA var. ELONGATUS Payne, n. var.[1]

Plate 38, figures 2*a–c*

Carapace elongate, oblong in lateral view; greatest height slightly posterior of center, greatest length median or slightly above; hinge line straight, slightly less than maximum length, depressed, bounded anteriorly and posteriorly by obtuse angles; dorsal margin irregular; ventral margin and the two ends form a continuous semicircular arc; carinae highly developed; two prominent flanges extend from one cardinal angle to the other; inner flange continuous with the highly developed dorsal keel; position of anterior and posterior nodes indicated by outwardly curving carinae extending down from the dorsal keel, becoming very faintly developed below the kirkbyan pit; median node large, hemispherical, developed near center of carapace; kirkbyan pit subelliptical in shape, on under side of median node and slightly posterior to the center; reticulations cover all of carapace except margin and carinae, smaller in size on the median node. Length, 0.78 mm.; height, 0.41 mm.; thickness, 0.47 mm. Rare.

Remarks.—This form differs from *A. centronota* by being much more elongate. The form ratio of this specimen is 1.9 while the form ratio for *A. centronota* is 1.7. The carinae which indicate the position of the posterior and anterior nodes in this form join to form a continuous ridge, while the carinae in *A. centronota* die out beneath the kirkbyan pit.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3204.

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[1] The correct orthography of this common Pennsylvanian ostracode is in doubt. The specific term *centronota*, as originally published (*Kirkbya centronota* Ulrich and Bassler, 1906, U. S. Nat. Mus., Proc., vol. 30, p. 159, pl. 11, figs. 16, 17) is very probably, but not certainly, a typographical error, the inferred intended spelling being *centronata*. This is indicated by the following observations. (1) If the authors intended to compound their specific term from the Greek, *κεντρον* point or spur) and *νωτον* (back), the proper form of the specific term is *centronotum*, and since this is a neuter noun it should appear in unchanged form as a substantive in the nominative in apposition with the generic name, whatever the gender of the latter. The correct adjectival form of a specific term, derived from these roots, would have been *centronotiaea* (with *Kirkbya*) or *centronotiaeus* (with *Amphissites*). Clearly, it was not intended to use the adjectival form. It is conceivable that the authors meant to signify the plural form, *νωτα* (backs), and thus correctly to form *centronata* as a nominative substantive (neuter plural), for it would be grammatically proper to employ a plural substantive specific term with a generic name in the singular.

(2) The probable intended spelling is *Kirkbya centronata*, for the specific term is thus printed on page 161 of the authors' paper. *Centronata* is an adjective, from the Latin, meaning "with nodes or points." If it were clearly evident that this was the intended spelling, this shell would now be designated as *Amphissites centronatus*. The fact that *centronota* appears twice in the original paper, and *centronata* only once, creates doubt as to this interpretation.

Bassler and Kellett (Bibliographic index of Paleozoic Ostracoda, 1934, Geol. Soc. America, Spec. Paper 1, p. 149) incorrectly treat *centronota* as an adjective, writing "*Amphissites centronotus.*"

In the absence of rather clear indication (as required by Art. 19 of the International Rules) of existence of a typographical error in the original publication, it seems best to let the spelling "*centronota*" stand, even though Dr. Bassler has just written to me saying that the originally intended spelling was *centronata*.

R. C. MOORE, *Editor.*

AMPHISSITES SULLIVANENSIS
Payne, n. sp.
Plate 38, figures 3*a–c*, 4

Carapace oblong-subquadrate in lateral view; hinge line straight, rather short; ends blunt in edge views, nearly equally rounded in side view; dorsal margin rather straight, slightly concave one-third length from anterior end; ventral margin nearly straight; ends smoothly rounded; greatest height one-fifth distance from anterior extremity; greatest length central; posterior node rather prominent, producing a bulge at posterior cardinal angle; central node large, but low and ill-defined, connected with posterior node by a broad ridge; anterior node poorly defined; pit on ventral side of central node, elongate, axis pointing obliquely upward toward the posterior node; outer flange represented on the posterior and anterior margins by a thin raised line, not present on dorsal and ventral margins; reticulations medium size, even, distinct, smaller on the median node. Measurements of figured specimens: Plate 38, figures 3*a–c:* length, 0.90 mm.; height, 0.50 mm.; thickness, 0.45 mm. Figure 4: length 0.87 mm.; height, 0.50 mm. Form ratio: fig. 3, 1.8; fig. 4, 1.74. Common.

Remarks.—This species is much thicker than *A. rothi*. The central and posterior nodes of *A. rothi* are more sharply defined than those of this species. *A. pinguis* has a sulcus between the central and posterior nodes and does not have the smaller reticulations on the central node as does this species. *A. pinguis* is also smaller than this species.

Types.—Holotypes, Indiana Univ., Paleont. Coll., 3205; paratype, 3206.

Genus KNIGHTINA Kellett, 1933

KNIGHTINA FIDLARI Payne, n. sp.
Plate 38, figures 5*a–c*

Carapace suboblong; greatest height one-sixth length from anterior extremity; greatest length median; dorsal margin nearly straight; ventral margin slightly concave; ends smoothly rounded except the antero-ventral slope which forms a rather sharp angle; hinge line straight; shallow sulcus extending from just below the kirkbyan pit in a gentle curve to the postero-dorsal extremity; shallow groove extends diagonally across postero-ventral portion of carapace; poorly developed shoulder extends from the postero-dorsal region diagonally across the carapace to and including the kirkbyan pit; kirkbyan pit nearly circular, slightly below median line and slightly posterior to center; reticulations medium in size, even, distinct. Length, 0.77 mm.; height, 0.42 mm.; thickness, 0.38 mm. Form ratio, 1.83. Common.

Remarks.—This form resembles *Roundyella simplicissima* but differs in the presence of sulci and the shoulder in the postero-dorsal portion. It also differs in the position of the kirkbyan pit.

This species is named for Mr. Marion M. Fidlar, of Indiana University, who helped collect the material.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3207.

KNIGHTINA FIDLARI var. OBLONGA
Payne, n. var.
Plate 38, figures 6*a–c*

This form is very close to *K. fidlari*, but is more oblong in shape and more elongate. The form ratio of this variety is 2.07, while the form ratio of *K. fidlari* is 1.83. The dorsal and ventral margins of this variety are nearly parallel. Length, 0.85 mm.; height, 0.41 mm.; thickness, 0.39 mm. Rare.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3208.

KNIGHTINA HARLTONI Kellett
Plate 38, figures 7*a, b*

Knightina harltoni KELLETT, *1933*, Jour. Paleontology, vol. 7, no. 1, p. 99, pl. 16, figs. 1–7. Lansing formation, eastern Kansas.

Carapace oblong in lateral view; greatest thickness at the postero-dorsal

shoulder and tapering slightly to the anterior node, greatest length median; hinge line straight, slightly less than maximum length, depressed, ends nearly equally rounded. Postero-dorsal shoulder prominent and angular, with a steep posterior slope, anterior slope very slight and continuing almost unbroken to the posterior flange; central node represented by a faint ridge trending diagonally toward the postero-cardinal angle, most prominent just above muscle spot; two outer flanges extend from one cardinal angle to the other, above them and separated by two rows of reticulation meshes is the unreticulated inner flange; muscle spot large, circular, non-reticulate area with no rim and not depressed, encircled by nine reticulation pits; reticulations cover all of carapace except margin and flanges. Length, 0.93 mm.; height, 0.48 mm.; thickness, 0.34 mm. Form ratio, 1.93. Rare.

Type.—Hypotype, Indiana Univ., Paleont. Coll., 3209.

Family BAIRDIIDAE Sars, 1887

Genus BAIRDIA McCoy, 1844

BAIRDIA ANOMALA Payne, n. sp.
Plate 38, figures 8*a*, *b*

Carapace elongate; greatest length and height central; dorsal margin arched; postero- and antero-dorsal slopes nearly straight; ventral margin nearly straight in central and anterior portions, curving smoothly upward at posterior end; posterior end rather sharply acuminate; anterior end bluntly rounded, nearly vertical; overlap strong on dorsal margin, weak on ventral margin, absent on anterior margin. Length, 1.08 mm.; height, 0.62 mm.; thickness, 0.48 mm. Form ratio, 1.7. Rare.

Remarks.—The absence of overlap on the anterior end distinguishes this species from *B. dornickhillensis*.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3210.

BAIRDIA BEEDEI Ulrich and Bassler
Plate 38, figures 9*a*, *b*;
Plate 39, figures 1*a*, *b*

Bairdia beedei ULRICH and BASSLER, *1906*, U. S. Nat. Mus., Proc., vol. 30, p. 161, pl. 11, figs. 19, 20. Florena shale, Kansas.; *1923*, Maryland Geol. Survey, Silurian volume, p. 319, text fig. 3 (original figure redrawn.)—WARTHIN, *1930*, Oklahoma Geol. Survey, Bull. 53, p. 69, pl. 5, figs. 9*a*, *b*. Holdenville formation, Oklahoma.—UPSON, *1933*, Nebraska Geol. Survey, Bull. 8, 2d ser., p. 16, pl. 1, figs. 4*a–c*. "Garrison" shale, Kansas.—KELLETT, *1934*, Jour. Paleontology, vol. 8, no. 2, p. 123, pl. 14, figs. 1*a–h*, 2. Stanton limestone, Kansas.

Bairdia beedei abrupta ULRICH and BASSLER, *1906*, U. S. Nat. Mus., Proc., vol. 30, p. 161, pl. 11, figs. 21, 22. Florena shale, Kansas.

Bairdia hispida HARLTON, *1928*, Jour. Paleontology, vol. 2, p. 140, pl. 21, fig. 14. Cisco group, Texas.; *1929*, Texas Univ., Bull. 2901, p. 155, pl. 3, figs. 2*a*, *b*. Graham formation, Texas.—DELO, *1930*, Jour. Paleontology, vol. 4, no. 2, p. 163, pl. 12, figs. 14*a*, *b*. Graham formation, Menard County, Texas.

Bairdia moorei KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 318, pl. 43, figs. 1*a–c*. Fort Scott limestone, Missouri.—CORYELL

EXPLANATION OF PLATE 38

FIGS. *1*—*Antiparaparchites wabashensis* Payne, n. sp., ×40. *a*, Right valve; *b*, dorsal view. (p. 279)

2—*Amphissites centronota* var. *elongatus* Payne, n. var., ×40. *a*, Left valve; *b*, dorsal view; *c*, posterior view. (p. 280)

3, *4*—*Amphissites sullivanensis* Payne, n. sp., ×40. *3a*, Left valve; *3b*, dorsal view; *3c*, posterior view. *4*, Left valve. (p. 281)

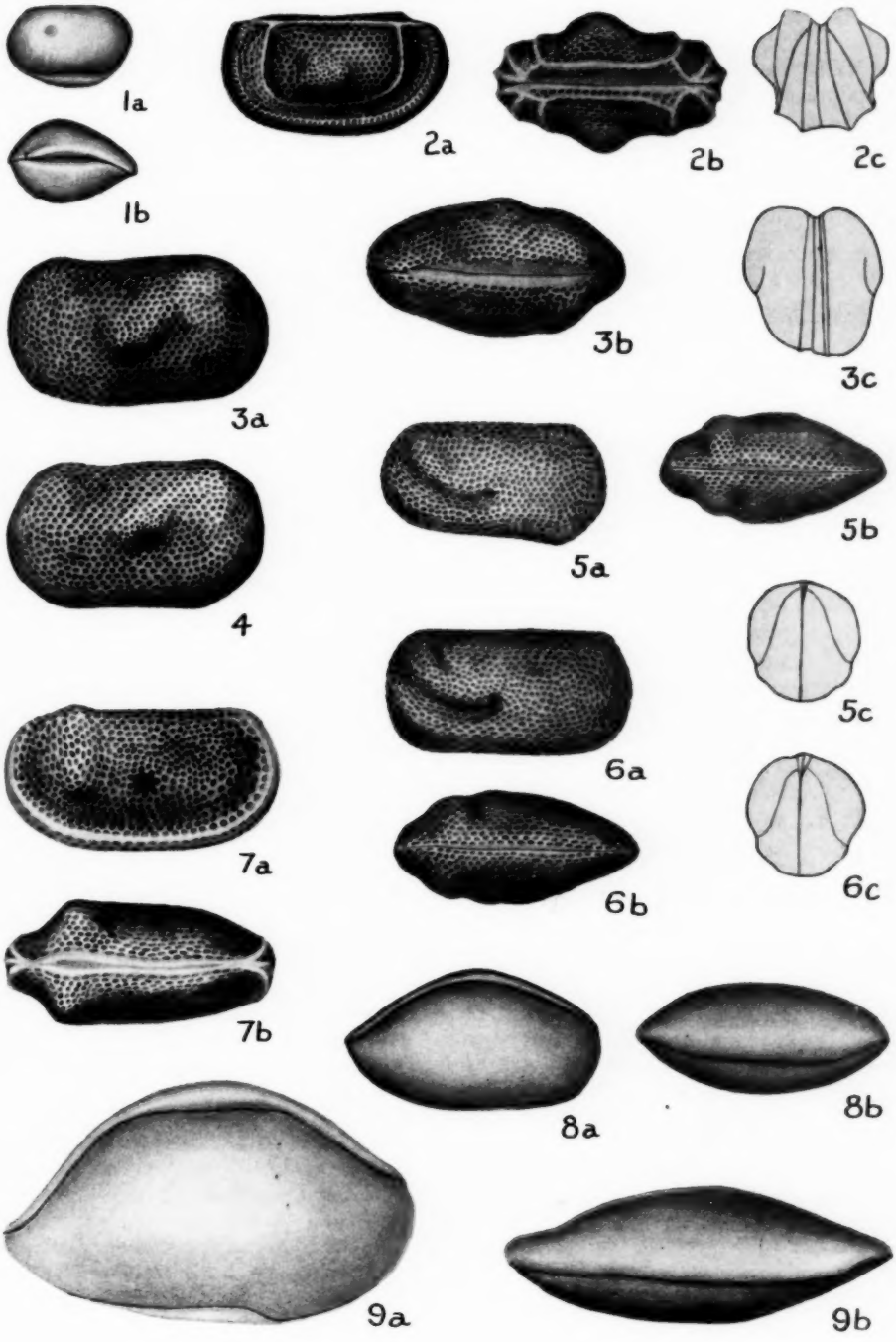
5—*Knightina fidlari* Payne, n. sp., ×40. *a*, Right valve; *b*, dorsal view; *c*, posterior view. (p. 281)

6—*Knightina fidlari* var. *oblonga* Payne, n. var., ×40. *a*, Right valve; *b*, dorsal view; *c*, posterior end view. (p. 281)

7—*Knightina harltoni* Kellett, ×40. *a*, Right valve; *b*, dorsal view. (p. 281)

8—*Bairdia anomala* Payne, n. sp., ×32. *a*, Right valve; *b*, dorsal view. (p. 282)

9—*Bairdia beedei* Ulrich and Bassler, ×40. *a*, Right valve; *b*, dorsal view. (p. 282)



Payne, Pennsylvanian Ostracodes

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and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, no. 2, p. 33. Nowata shale, Oklahoma.—CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, no. 4, p. 173, pl. 17, fig. 4. Wayland shale, Texas.
Bairdia wrefordensis UPSON, *1933*, Nebraska Geol. Survey, Bull. 8, 2d ser., p. 22, pl. 2, figs. 5*a*, *b*. Fourmile limestone, Kansas.

Carapace large, subovate in lateral view; dorsal margin roundly arched, antero-dorsal slope slightly concave; postero-dorsal slope steep, bending outward slightly near the middle; ventral margin slightly convex; anterior end broadly rounded, the extremity definitely below the dorsal anterior angle and near the median line; greatest height central; greatest thickness slightly anterior to the center; overlap strongest on the dorsal border, antero-dorsal slope, and at the middle of the ventral margin; dorsal commissure line consisting of three nearly straight lines; highest point on the line of commissure definitely anterior to the highest point on the dorsal margin. Plate 38, figures 9*a*, *b:* length, 1.39 mm; height, 0.82 mm.; thickness, 0.45 mm. Form ratio, 1.73. Plate 39, figures 1*a*, *b:* length, 1.20 mm.; height, 0.75 mm.; thickness, 0.44 mm. Form ratio, 1.6. Common.

Type.—Hypotype, Indiana Univ., Paleont. Coll., 3211, 3212.

BAIRDIA BEEDEI var. INFLATA Payne, n. var.
Plate 39, figures 2*a*, *b*

Carapace subquadrate in lateral view; dorsal margin arched, antero-dorsal slope straight or slightly concave; postero-dorsal slope rather straight, bending outward slightly near the middle; ventral margin broadly convex; anterior end rather broadly rounded; posterior end bluntly pointed; greatest length and height central; greatest thickness slightly posterior to center; overlap best developed on dorsal margin and at the middle of the ventral margin. Length, 0.90 mm.; height, 0.58 mm.; thickness, 0.42 mm. Form ratio, 1.4. Rare.

Remarks.—This form undoubtedly belongs to the *B. beedei* group. The commissure line in the dorsal region has the characteristic double angle. The form ratio of this variety is much shorter than that of *B. beedei*, whose form ratio varies from 1.6 to 1.7. The carapace of this form is more inflated than that of *B. beedei*.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3213.

BAIRDIA BRADFIELDI Payne, n. sp.
Plate 39, figures 3*a*, *b*

Carapace elongate, inflated, length nearly twice the height; greatest length diagonally through center; greatest height and thickness central; dorsal and ventral margins slightly convex; postero-dorsal slope steep, slightly concave; posterior end bluntly pointed; antero-ventral slope steep, slightly convex; anterior end broadly acuminate; overlap strongest on dorsal and ventral margins, dying out at postero-dorsal angle; anterior end shows no overlap. Length, 0.95 mm.; height, 0.54 mm.; thickness, 0.48 mm. Form ratio, 1.75. Rare.

Remarks.—This form differs from *B. radlerae* in that the anterior end is not raised as high.

This species is named for Dr. H. H. Bradfield, of Fort Worth, Texas.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3214.

BAIRDIA GIBBOSA Payne, n. sp.
Plate 39, figures 4*a*, *b*

Carapace subrhomboidal in lateral view; inflated; greatest length, height, and thickness central; antero-dorsal slope straight to slightly concave, postero-dorsal slope steep and slightly concave; bluntly acuminate posteriorly; ventral border gently convex, rounding up evenly to posterior and anterior ends; overlap moderately strong on dorsal margin, postero- and antero-dorsal slopes, and on central portion of ventral margin; overlap weak on anterior margin with no overlap on postero-ventral slope. Length, 1.21 mm.; height, 0.89 mm.; thickness, 0.75 mm. Form ratio, 1.3. Rare.

Remarks.—This form differs from *B. blakei* in that it is much higher.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3215.

BAIRDIA HOOVERAE Kellett
Plate 39, figures 5*a*, *b*

Bairdia hooverae KELLETT, *1934*, Jour. Paleontology, vol. 8, p. 126, pl. 14, figs. 5*a*, *b*. Shawnee group, Kansas.

Carapace short, ovoid in lateral view; strongly inflated; greatest height central; greatest thickness central; dorsal margin evenly arched; ventral margin nearly straight in central half; anterior end broadly rounded, semicircular in outline, merging smoothly into the ventral margin; posterior end more narrowly rounded, not acuminate; dorsal overlap narrow and even. Length, 1.19 mm.; height, 0.86 mm.; thickness, 0.72 mm. Form ratio, 1.41. Rare.

Type.—Hypotype, Indiana Univ., Paleont. Coll., 3216.

BAIRDIA HOXBARENSIS Harlton
Plate 39, figures 6*a*, *b*

Bairdia hoxbarensis HARLTON, *1927*, Jour. Paleontology, vol. 1, p. 211, pl. 33, fig. 12. Hoxbar formation, Carter County, Oklahoma.—KELLETT, *1934*, Jour. Paleontology, vol. 8, p. 131, pl. 16, figs. 5*a–c*. Marmaton to Wreford, Kansas.

Bairdia subelongata HARLTON, *1927*, Jour. Paleontology, vol. 1, pp. 210, 211, pl. 33, fig. 11. Upper "Glenn" beds, Carter County, Oklahoma.—KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 326, pl. 43, fig. 9. Lower Marmaton, St. Louis County, Missouri.—HARLTON, *1929*, Texas Univ., Bull. 2901, p. 157, pl. 3, figs. 6*a–d*. Graham formation, Menard County, Texas.

Bairdia haworthi KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 325, pl. 43, figs. 7*a*, *b*. Lower Marmaton beds, St. Louis County, Missouri.—WARTHIN, *1930*, Oklahoma Geol. Survey, Bull. 53, p. 72, pl. 6, figs. 4*a*, *b*. Wetumka to Holdenville formations, Oklahoma.

Bairdia acetalata CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, no. 4, p. 173, pl. 17, fig. 5. Wayland shale, Texas.—CORYELL and BOOTH, *1933*, Am. Midland Naturalist, vol. 14, no. 3, p. 263, pl. 3, figs. 10, 11. Wayland shale, Texas.—UPSON, *1933*, Nebraska Geol. Survey, 2d ser., Bull. 8, p. 17, pl. 1, fig. 5*a*. Eiss limestone, Nebraska.

Bairdia nebraskensis UPSON, *1933*, Nebraska Geol. Survey, Bull. 8, 2d ser., p. 18, pl. 1, figs. 6*a*, *b*. Fourmile limestone, Kansas.

Carapace large, elongate, suboblong in lateral view; greatest height and thickness one-third length from posterior end; dorsal margin slightly convex; posterior end acuminate; postero-dorsal and postero-ventral slopes nearly evenly convex; anterior end evenly convex, semicircular; ventral margin long, concave near central third, concavity greatest anterior to center; overlap moderately strong on dorsal margin, dying out abruptly near anterior end; overlap weak on ventral margin, restricted to central one-eighth of carapace; surface smoothly convex. Length, 1.23 mm.; height, 0.50 mm.; thickness, 0.35 mm. Form ratio, 2.46. Abundant.

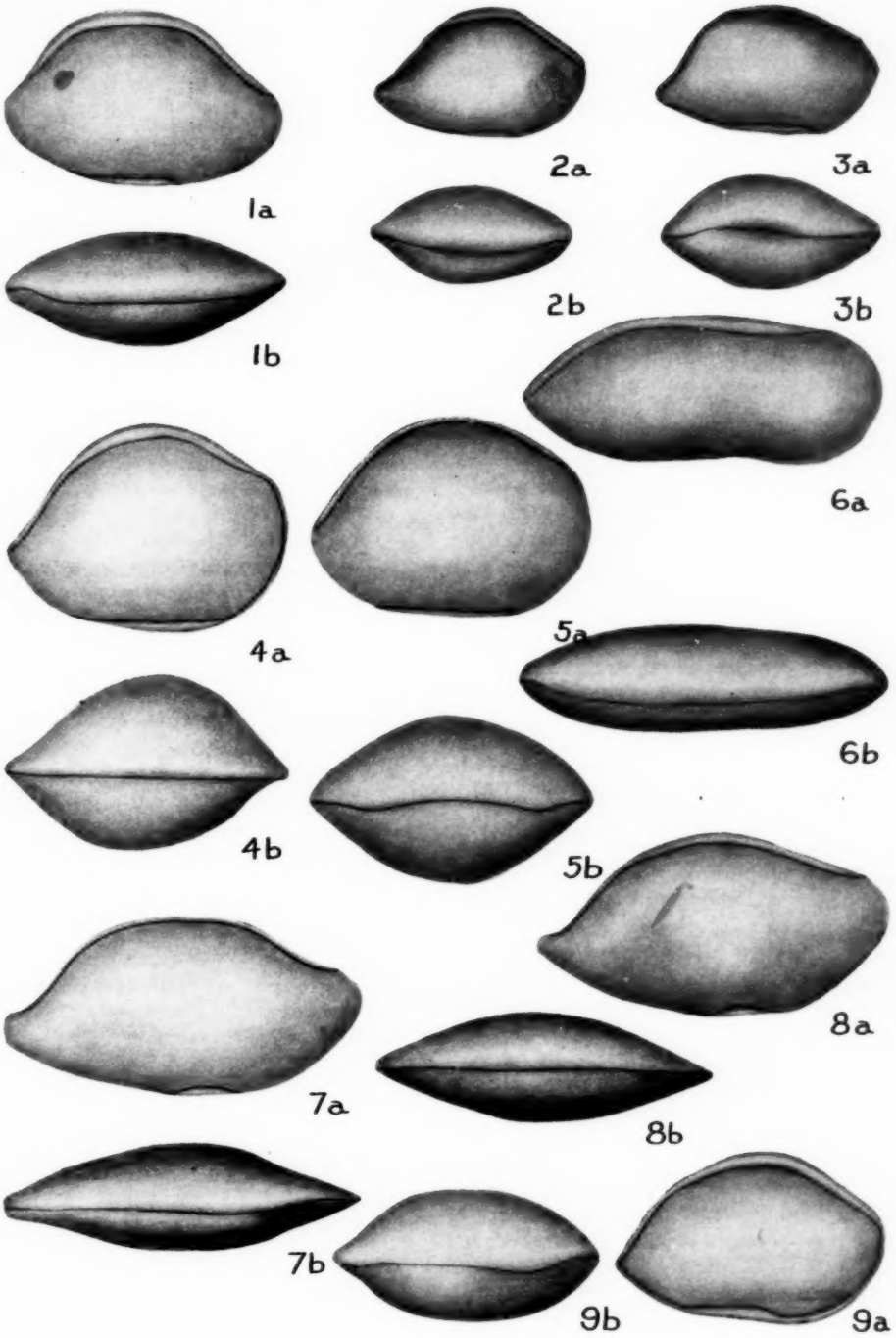
Type.—Hypotype, Indiana Univ., Paleont. Coll., 3217.

BAIRDIA POMPILIOIDES Harlton
Plate 39, figures 7*a*, *b*, 8*a*, *b*

Bairdia pompilioides HARLTON, *1928*, Jour. Paleontology, vol. 2, p. 140, pl. 21, fig. 13. Upper "Glenn" [Hoxbar] formation, Ardmore Basin, Oklahoma; *1929*, Texas Univ., Bull. 2901, p. 154, pl. 2, fig. 7; pl. 3, fig. 8. Graham formation, Menard County, Texas.

EXPLANATION OF PLATE 39

FIGS. *1*—*Bairdia beedei* Ulrich and Bassler, ×32. *a*, Right valve; *b*, dorsal view. (p. 282)
2—*Bairdia beedei* var. *inflata* Payne, n. var., ×32. *a*, Right valve; *b*, dorsal view. (p. 283)
3—*Bairdia bradfieldi* Payne, n. sp., ×32. *a*, Right valve; *b*, dorsal view. (p. 283)
4—*Bairdia gibbosa* Payne, n. sp., ×32. *a*, Right valve; *b*, dorsal view. (p. 283)
5—*Bairdia hooverae* Kellett, ×32. *a*, Right valve; *b*, dorsal view. (p. 284)
6—*Bairdia hoxbarensis* Harlton, ×40. *a*, Right valve; *b*, dorsal view. (p. 284)
7, *8*—*Bairdia pompilioides* Harlton. *7a*, Right valve; *7b*, dorsal view, ×40. *8a*, Right valve; *8b*, dorsal view, ×32. (p. 284)
9—*Bairdia seminalis* Knight, ×32. *a*, Right valve; *b*, dorsal view. (p. 285)



Payne, Pennsylvanian Ostracodes

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WARTHIN, *1930*, Oklahoma Geol. Survey, Bull. 53, p. 70, pl. 5, figs. 11*a*, *b*. Holdenville formation, Oklahoma.—CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, no. 2, p. 33. Nowata shale, Tulsa County, Oklahoma.—KELLETT, *1934*, Jour. Paleontology, vol. 8, no. 2, p. 130, pl. 16, figs. 2*a*, *b*; 3*a*, *b*; 4*a*, *b*. Lower Marmaton group, Pennsylvanian, to Wreford formation, Permian, Kansas.—BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 87, pl. 6, figs. 15*a*, *b*. Hoxbar formation, Oklahoma.

Bairdia subcitriformis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 322, pl. 43, figs. 5*a*, *b*. Pawnee limestone, Clayton formation, St. Louis County, Missouri.

Carapace very large, elongate; greatest height and thickness in central third; dorsal margin broadly arched; antero-dorsal and postero-dorsal slopes both concave; posterior beak long, prominent, and upturned; anterior end bluntly pointed and turned slightly upward; ventral margin slightly convex, nearly straight in central portion; overlap broad on dorsal margin, narrowing gradually toward each end; overlap conspicuous on ventral border only in central part. Measurements of figured specimens: Plate 39, figs. 7*a*, *b:* length, 1.5 mm.; height, 0.78 mm.; thickness, 0.47 mm. Form ratio, 1.92. Figs. 8*a*, *b:* length, 1.23 mm.; height, 0.61 mm.; thickness, 0.37 mm. Form ratio, 2.01. Abundant.

Type.—Hypotype, Indiana Univ., Paleont. Coll., 3218, 3219.

BAIRDIA SEMINALIS Knight

Plate 39, figures 9*a*, *b*

Bairdia seminalis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 320, pl. 43, figs. 2*a–d*. Lower Marmaton formation, St. Louis County, Missouri.—KELLETT, *1934*, Jour. Paleontology, vol. 8, p. 127, pl. 15, figs. 2*a–c*. Stanton limestone, Kansas.

Bairdia crassa DELO (not Harlton, 1929), *1930*, Jour. Paleontology, vol. 4, p. 164, pl. 12, fig. 15. Fort McKavett, Texas; *1931*, Washington Univ. Studies, n. ser., Sci. and Technology, no. 5, p. 49, pl. 1, fig. 9. Graham formation, Menard County, Texas.

Bairdia samplei CORYELL and BOOTH, *1933*, Am. Midland Naturalist, vol. 14, no. 3, p. 264, pl. 3, figs. 12, 13. Wayland shale, Graham County, Texas.

Bairdia tumida UPSON, *1933*, Nebraska Geol. Survey, Bull. 8, 2d ser., p. 21, pl. 2, figs. 3*a–c*. Cottonwood-Florena contact, Permian, Kansas.

Carapace subrhomboidal in lateral view; highly inflated; greatest height two-thirds length from posterior end; dorsal margin rather highly arched; posterior beak bluntly acuminate; postero-dorsal slope slightly convex; antero-dorsal slope straight; ventral border convex, turns sharply toward the high, sharply rounded anterior end; overlap greatest on the antero-dorsal slope and in the center of the ventral margin. Length, 1.14 mm.; height, 0.71 mm.; thickness, 0.55 mm. Form ratio, 1.6. Rare.

Remarks.—This specimen was identified with *B. tumida* Upson, but since Miss Kellett examined the types of *B. tumida* and placed it in synonomy with *B. seminalis*, it is therefore referred to the latter species.

Type.—Hypotype, Indiana Univ., Paleont. Coll., 3220.

Genus BYTHOCYPRIS Brady, 1880

BYTHOCYPRIS HAYDENBRANCHENSIS Payne, n. sp.

Plate 40, figures 1*a*, *b*

Carapace elongate, pediform in lateral view; length more than twice the height; greatest height central; greatest length below center, obliquely across carapace from postero-ventral angle to anterior extremity; dorsal margin convex, more strongly so in posterior than in anterior half; anterior extremity straight; ventral margin long, nearly straight; posterior end sharply angled; overlap even on dorsal border and on postero- and antero-dorsal slopes; surface smooth. Length, 1.23 mm.; height, 0.58 mm.; thickness, 0.43 mm. Form ratio, 2.1. Rare.

Remarks.—Until the generic name of this genus is correctly determined (*Bythocypris* or *Cytherellina*), this form must be placed with the genus *Bythocypris*. This species is nearly twice as large as most of the species of *Bythocypris* as yet described and, as a result, should per-

haps be included under Bradfield's genus *Bairdiacypris*.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3221.

BYTHOCYPRIS REGULARIS Payne, n. sp.
Plate 40, figures 2*a*, *b*

Carapace subelliptical in lateral view; greatest height central; greatest thickness slightly posterior to center; dorsal margin lowly arched, sloping down with gentle convexity to the rounded anterior end; ventral margin broadly convex; postero-ventral region somewhat truncated, causing a rather sharp angle at the posterior extremity; overlap strongest on dorsal margin, antero- and postero-dorsal slopes, and on the middle one-third of the ventral margin; surface smooth. Length, 0.75 mm.; height, 0.55 mm.; thickness, 0.35 mm. Form ratio, 1.36. Abundant.

Remarks.—This form does not possess the straight ventral margin of *B. tomlinsoni*. The form ratio of *B. subpediformis* is too great.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3222.

Genus HEALDIA Roundy, 1926

HEALDIA MALOTTI Payne, n. sp.
Plate 40, figures 3*a*, *b*

Carapace small, subdeltoid in lateral view; postero-dorsal slope slightly concave; antero-dorsal slope straight; ventral margin nearly straight but curving gradually into the rounded ends; posterior margin truncated dorsally; both valves much thicker posterior with a rather inconspicuous ridge; overlap distinct; greatest height slightly posterior to center; greatest length central; greatest width one-third length from posterior end; surface smooth; no spines. Length, 0.45 mm.; height, 0.30 mm.; thickness, 0.15 mm. Form ratio, 1.5. Very rare.

Remarks.—This species somewhat resembles *H. simplex* but is much thinner in the anterior half. It differs from *H. caneyensis* in being less pointed in the anterior and posterior margins as shown in the dorsal view. Absence of spines and subdeltoid shape distinguish it from *H. ciscoensis*.

This species is named for Prof. C. A. Malott of Indiana University, who discovered the material on which this paper is based.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3223.

Family CYTHERELLIDAE Sars, 1865

Genus CYTHERELLA Jones, 1849

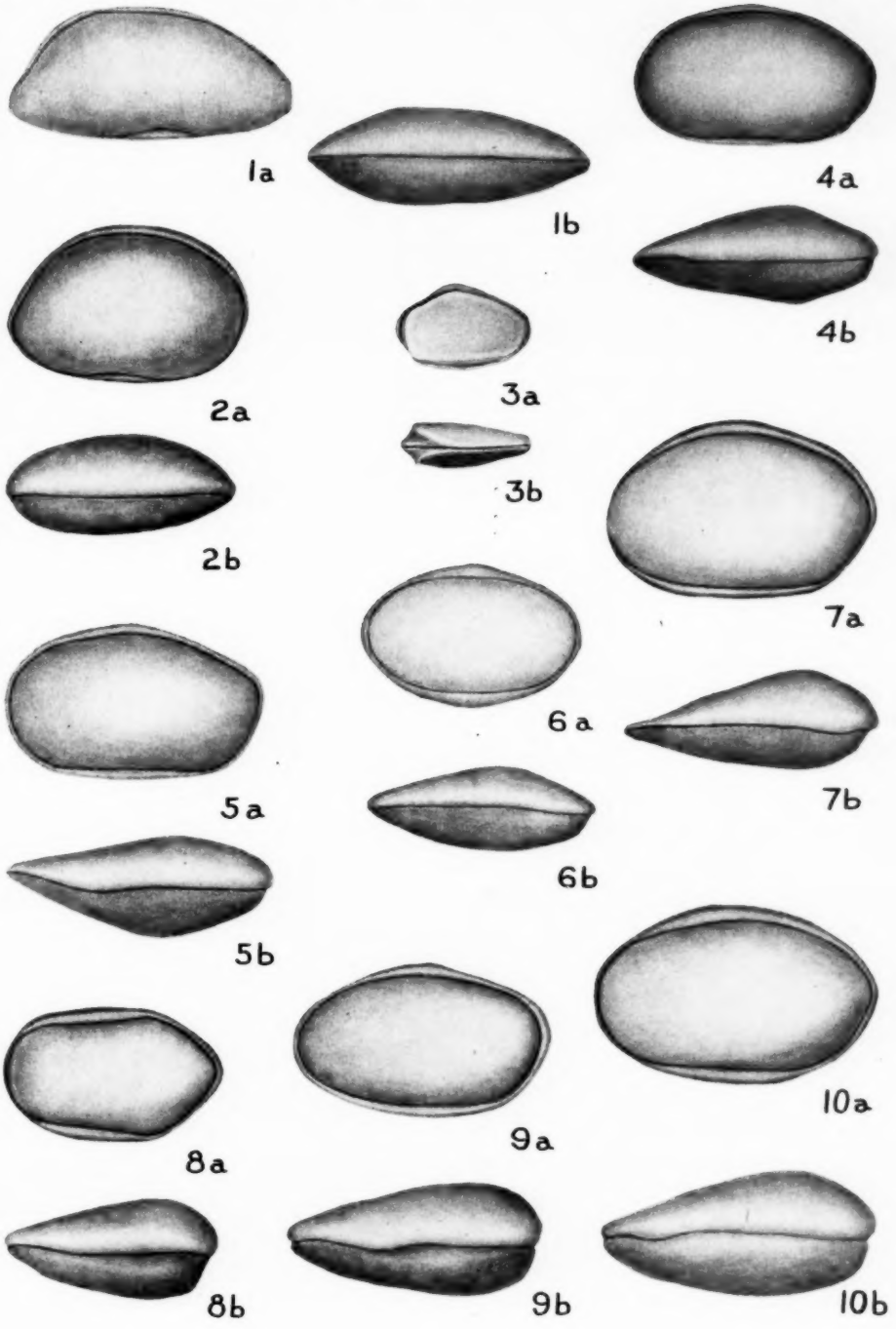
CYTHERELLA DAUBEANA Bradfield
Plate 40, figures 4*a*, *b*

Cytherella daubeana BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 131, pl. 11, figs. 8*a*, *b*. Hoxbar formation, Oklahoma.

Carapace elongate, subovate in lateral view; flatly rhomboidal in dorsal view; greatest length median; greatest height central; greatest thickness one-third length from posterior end; valves about equally inflated; dorsal margin lowly arched, slopes about equally convex;

EXPLANATION OF PLATE 40

FIGS. *1*—*Bythocypris haydenbranchensis* Payne, n. sp., ×32. *a*, Right valve; *b*, dorsal view. (p. 285)
2—*Bythocypris regularis* Payne, n. sp., ×40. *a*, Right valve; *b*, dorsal view. (p. 286)
3—*Healdia malotti* Payne, n. sp., ×40. *a*, Right valve; *b*, dorsal view. (p. 286)
4—*Cytherella daubeana* Bradfield, ×32. *a*, Left valve; *b*, dorsal view. (p. 286)
5—*Cytherella lirata* Bradfield, ×32. *a*, Left valve; *b*, dorsal view. (p. 287)
6—*Cytherella symmetrica* Payne, n. sp., ×32. *a*, Left valve; *b*, dorsal view. (p. 287)
7—*Cavellina altoides* Payne, n. sp., ×32. *a*, Left valve; *b*, dorsal view. (p. 287)
8—*Cavellina cumingsi* Payne, n. sp., ×40. *a*, Left valve; *b*, dorsal view. (p. 287)
9—*Cavellina laevissima* Bradfield, ×32. *a*, Left valve; *b*, dorsal view. (p. 288)
10—*Cavellina pulchella* Coryell, ×32. *a*, Left valve; *b*, dorsal view. (p. 288)



Payne, Pennsylvanian Ostracodes

UNIV. OF MICH.

ends about equally rounded, posterior end slightly more broadly rounded; ventral border nearly straight in central third, slopes about equally convex; overlap distinct, best developed dorsally and ventrally; dorsal commissure line broadly convex; ventral commissure line slightly concave; surface smooth. Length, 1.06 mm.; height, 0.61 mm.; thickness, 0.41 mm. Form ratio, 1.73. Rare.

Type.—Hypotype, Indiana Univ., Paleont. Coll., 3224.

CYTHERELLA LIRATA Bradfield
Plate 40, figures 5*a*, *b*

Cytherella lirata BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 131. pl. 11, figs. 8*a*, *b*. Hoxbar formation, Ardmore, Oklahoma.

Carapace elongate, subovate in lateral view; flattened subrhomboidal in dorsal view; greatest length obliquely above the center; greatest thickness slightly posterior to center; valves unequally inflated, the greatest convexity on the left is definitely posterior to center, and on the right valve at or slightly posterior to center, dorsal border arched, slopes about equal and only slightly convex; anterior end broadly rounded; posteriorly an angle of about 90 degrees is formed at the postero-dorsal angle; ventral border long, almost straight; overlap distinct, best developed on dorsal and ventral margins. Length, 1.1 mm.; height, 0.66 mm.; thickness, 0.43 mm. Form ratio, 1.66. Rare.

Type.—Hypotype, Indiana Univ., Paleont. Coll., 3225.

CYTHERELLA SYMMETRICA Payne, n. sp.
Plate 40, figures 6*a*, *b*

Carapace elliptical in lateral view; greatest length and height central; greatest thickness slightly posterior to center; dorsal and ventral borders sharply arched at center; postero- and antero-dorsal and ventral slopes slightly convex; anterior and posterior borders rather broadly rounded; overlap greatest dorsally and ventrally; surface smooth. Length, 0.95 mm.; height, 0.62 mm.; thickness, 0.37 mm. Form ratio, 1.5. Rare.

Remarks.—The dorsal and ventral halves of this form are nearly identical. Except for the slightly more convex right valve this species is nearly bilaterally symmetrical.

This form differs from *C. gloria* in the position of greatest height and nearly symmetrical form.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3226.

Genus CAVELLINA Coryell, 1928

CAVELLINA ALTOIDES Payne, n. sp.
Plate 40, figures 7*a*, *b*

Carapace subelliptical in lateral view; greatest height slightly anterior to center; greatest length through the center but slightly oblique; greatest thickness one-third length from posterior end; dorsal border convex; postero-dorsal slope nearly straight; anterior border broadly rounded; posterior margin rather sharply rounded; postero-ventral slope straight; ventral margin nearly straight; overlap best developed on dorsal and ventral margins; very slight overlap on anterior margin; surface smooth. Length, 1.13 mm.; height, 0.77 mm.; thickness, 0.43 mm. Form ratio, 1.4. Rare.

Remarks.—The degree of difference between this species and other closely related species is fully as great as that between other species and their closely related forms. This species closely resembles *Cytherella gloria* var. *alta* in lateral view, but the greatest thickness, as shown in the dorsal view, is definitely at the posterior end, which is characteristic of the genus *Cavellina*. As long as *Cavellina* and *Cytherella* are regarded as distinct genera, this species must be placed in *Cavellina*.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3227.

CAVELLINA CUMINGSI Payne, n. sp.
Plate 40, figures 8*a*, *b*

Carapace small, subelliptical in lateral view; greatest height near the middle;

greatest length median; greatest thickness one-fourth length from posterior end; dorsal and ventral margins nearly straight; anterior end broadly rounded; posterior margin narrowly rounded, with the extremity slightly above the median line; overlap strong, greatest dorsally and ventrally; surface smooth. Length, 0.75 mm.; height, 0.45 mm.; thickness, 0.35 mm. Very rare.

Remarks.—The length-height ratio of this specimen is 1.66 while the ratio for *C. pulchella* is 1.48. *C. pulchella* is much larger and more pointed posteriorly. This specimen is more pointed and has more overlap posteriorly than *C. subpulchella*.

This species is named for Prof. E. R. Cumings of Indiana University.

Type.—Holotype, Indiana Univ., Paleont. Coll., 3228.

CAVELLINA LAEVISSIMA Bradfield
Plate 40, figures 9*a*, *b*

Cavellina laevissima BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 133, pl. 12, figs. 6*a*, *b*; 7*a*, *b*. Hoxbar formation, Oklahoma.

Carapace subovate in lateral view; greatest height central; greatest length median; greatest thickness about one-fourth the length from the posterior end; dorsal border arched at the middle, both slopes nearly straight; anterior end evenly rounded; posterior end more narrowly rounded; ventral margin slightly convex; overlap widest dorsally and ventrally; surface smooth. Length, 1.11 mm.; height, 0.65 mm.; thickness, 0.47 mm. Form ratio, 1.7. Rare.

Type.—Hypotype, Indiana Univ. Paleont. Coll., 3229.

CAVELLINA PULCHELLA Coryell
Plate 40, figures 10*a*, *b*

Cavellina pulchella CORYELL, *1928*, Jour. Paleontology, vol. 2, p. 90, pl. 11. fig. 5. Seminole and Holdenville formations, Oklahoma.—WARTHIN, *1930*, Oklahoma Geol. Survey, Bull. 53, p. 78, pl. 7, figs. 3*a*, *b*. Holdenville formation, Oklahoma.—CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, p. 181, pl. 17, fig. 16. Wayland shale, Texas.—CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 273, pl. 26, fig. 15. East Mountain shale, Mineral Wells formation, Texas.—BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 131, pl. 12, figs. 2*a*, *b*. Deese formation, Oklahoma.

Carapace subelliptical in lateral view; greatest height near the middle; greatest length median; greatest thickness at the posterior end; dorsal margin arched; anterior margin broadly rounded; posterior margin narrowly rounded at the median line; ventral border convex; overlap greatest ventrally and antero-dorsally; surface smooth. Length, 1.20 mm.; height, 0.77 mm.; thickness, 0.52 mm. Form ratio, 1.55. Rare.

Type.—Hypotype, Indiana Univ., Paleont. Coll., 3230.

KENNETH A. PAYNE, INDIANA UNIVERSITY, BLOOMINGTON, INDIANA. PRESENT ADDRESS, SUN OIL COMPANY, DALLAS, TEXAS. MANUSCRIPT RECEIVED BY THE EDITOR, JULY 11, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 4, PP. 289–305, PLS. 41–43,
1 TEXT FIG., JUNE, 1937

THE TRANQUILLA SHALE (UPPER EOCENE) OF PANAMA AND ITS FORAMINIFERAL FAUNA

H. N. CORYELL and JOHN R. EMBICH

ABSTRACT

The basal Tertiary beds of the upper Chagres River Valley, Panama, which, until now, have been included in the Bohio formation, classed as Oligocene in age, are here named the Tranquilla shale. On the basis of its microfauna, the Tranquilla shale is regarded as Jackson (late Eocene) in age. The fauna consists of 64 species and varieties of Foraminifera, 26 of which are new. Figures of all of the specimens identified are given for comparison. Only the new forms are described.

STRATIGRAPHY OF THE TRANQUILLA SHALE

This Chagres River Valley in Panama offers unusual opportunity for the study of the Tertiary stratigraphy of the region. The sediments appear to offlap from the source of the river to its mouth, for as one goes up the river, he passes over older and older formations until the andesitic basement rocks are reached. These constitute the valley floor in the upper reaches of the Chagres River and in the valley of the Rio Pequeni, its tributary.

Ross and Reeves (1931) gave the name Bohio to the entire group of sediments in the Chagres Valley above Madden Dam, and referred them to the Oligocene. The samples of Foraminifera which were collected from the "Bohio formation," however, show that it includes both an upper Eocene and an Oligocene fauna. The Oligocene beds are well exposed near Bohio Switch; the Eocene beds appear farther east along the Rio Chagres, near the town of Tranquilla. Our Samples were collected from this latter area. Faunal study of them indicates late Eocene (Jackson) age.

This older formation requires a new name, and it is proposed here to call it the Tranquilla shale, from the town of Tranquilla, near which the formation is best exposed. The type locality is 79° 13′ West, 10° 15′ North (see fig. 1). The name Tranquilla was suggested by Mr. Robert Terry, who has carefully studied this region and who discovered the formation in the upper Chagres Valley. The Bohio formation is restricted to include only the Oligocene sediments which overlie the Tranquilla shale and which outcrop farther downstream.

The Tranquilla shale underlies many square miles of younger Tertiary formations covered by dense jungle in the Chagres River Valley. Judged from the nature and abundance of its fauna, the shale is believed to have been deposited in shallow water. It forms the base of the Tertiary column in the Chagres

Valley and is the oldest sedimentary formation which can be observed in Panama from the border of Costa Rica to the Province of Darien. It immediately overlies the andesitic basement in the upper Chagres Valley.

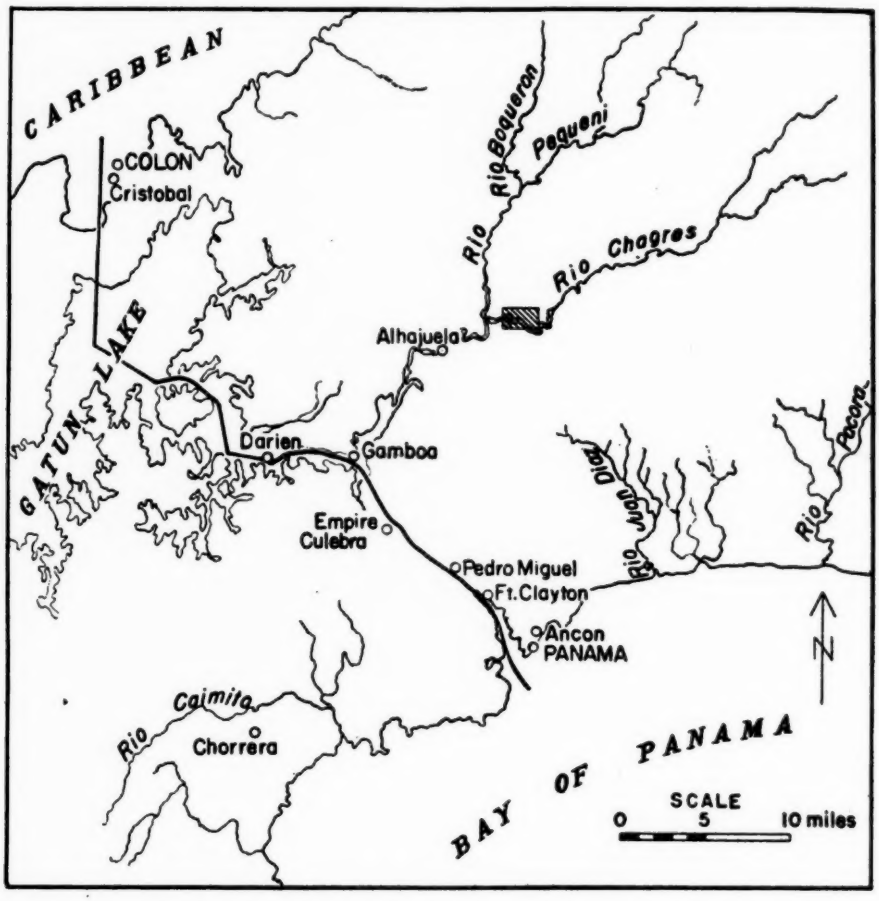


FIG. 1.—The shaded area on the Rio Chagres includes the type locality of the Tranquilla shale and other good outcrops.

The Tranquilla shale is a greenish-gray shale which changes easily to a waxy mud in wet outcrops. It contains, in addition to small fragments of feldspar, indigo-blue particles that are believed to be organic in origin. The most distinguishing characteristic of this shale is the finely preserved foraminiferal fauna. The samples yield a great abundance of typical Jackson foraminifera, such as *Hantkenina alabamensis* Cushman, *Bulimina jacksonensis* Cushman, and *Cibicides pseudoungarianus* Cushman, which are the three leading species. In addition, *Textularia hockleyensis* Cushman and Applin (n.

var.), *Nonion whitsettensis* Cushman and Applin, *Globorotalia cocoaensis* Cushman, *Dentalina jacksonensis* (Cushman and Applin), *Marginulina fragaria texasensis* Cushman and Applin are present. The association of forms indicates that the age of the fauna of the Tranquilla shale is Jackson, or late Eocene. Additional evidence for the Eocene age of the Tranquilla shale is presented by the very limited number of its species which enter the Oligocene. By comparison with previously published check lists of upper Eocene faunas (Cushman, 1935; Ellisor, 1933; Howe and Wallace, 1932; Monsour, 1937; Plummer, 1932), it is possible to suggest a tentative correlation with the McElroy division of the Jackson, because of the presence in the Tranquilla of a variety of *Textularia hockleyensis*, which is a guide to the McElroy, and the characteristic species, *Dentalina jacksonensis*, *Eponides jacksonensis*, *Haplophragmoides dibollensis*, and *Robulus alato-limbatus*. If this correlation is valid, there is an unconformity at the top of the Eocene beds in the Chagres Valley, represented by at least part of the Whitsett, or topmost Jackson, of Texas.

ACKNOWLEDGMENTS

We express appreciation of the work done by Mr. Robert Terry, who has made detailed stratigraphic determinations in Panama, and who, after having studied the formations of the Chagres River Valley, suggested the name Tranquilla shale for the formation treated in this paper.

Illustrations of Foraminifera were drawn by Miss Miriam B. Pollak of Columbia University. Miss Doris Malkin of Columbia University assisted in revision and preparation of the manuscript for publication.

Check List of Upper Eocene Foraminifera from the Tranquilla Shale

Species	Oligocene	Jackson Eocene, Gulf Coast			Upper Eocene, other areas
		Lower	Middle	Upper	
Ammobaculites humboldti	x	—	—	—	x
Ammomarginulina tranquillensis, n. sp.					
Anomalina pacoraensis, n. sp.					
Angulogerina sanjuanensis, n. sp.					
Astacolus sp.					
Asterocyclina gamboaensis, n. sp.					
Bolivina malkinae, n. sp.					
Bolivina tranquilla, n. sp.					
Bolivinoides planulis, n. sp.					
Bulimina inflata	x	—	—	—	?
Bulimina jacksonensis	x	x	x	x	x
Bulimina pyrula	—	x	x	x	—
Ceratobulimina alazanensis	x	—	—	—	—
Chilostomella grandis					
Cibicides pseudoungerianus	—	x	—	—	x
Cornuspira olygogyra	?	x	x	x	x
Cycloloculina annulata					
Dentalina consobrina emaciata	—	x	x	x	—
Dentalina cooperensis	—	—	—	—	x
Dentalina jacksonensis	—	x	x	x	x

Check List of Upper Eocene Foraminifera from the Tranquilla Shale—Continued

Species	Oligocene	Jackson Eocene, Gulf Coast			Upper Eocene, other areas
		Lower	Middle	Upper	
Frondicularia tenuissima	x	—	x	x	x
Epistomina elegans	—	x	x	x	—
Eponides jacksonensis	—	x	x	x	x
Globorotalia cocoaensis	—	x	x	x	x
Gyroidina guayabalensis	—	—	—	—	x(?)
Hantkenina alabamensis	(x)	x	x	x	x
Haplophragmoides dibollensis	—	—	x	x	x
Heterostomella sp.					
Lagena costata	—	x	x	x	x
Lagenoglandulina subovata var. *chagresensis*, n. var.					
Lagenoglandulina napaeformis					
Lamarckina curryi, n. sp.					
Lamarckina hispida, n. sp.					
Liebusella baylesi, n. sp.					
Listerella anconensis, n. sp.					
Loxostoma dalli	—	—	x	x	x
Marginulina alazanensis	x	—	—	—	—
Marginulina fragaria var. *texasensis*	—	x	x	x	—
Marginulina subbullata	?	—	—	—	x
Marginulina triangularis var. *panamensis*, n. var.					
Nodogenerina cooperensis	—	—	—	x	x
Nodosaria radicula	—	x	x	x	x
Planularia thalmanni	—	—	—	—	x
Plectofrondicularia cookei	x	x	x	x	x
Plectofrondicularia vaughani	x	—	—	x	x
Psammosphaera parva					
Reophax colonensis, n. sp.					
Reophax parsonsensis, n. sp.					
Robulus alato-limbatus	—	x	x	x	x
Robulus arcuato-striatus var. *carolinianus*	—	x	x	x	x
Robulus terryi, n. sp.					
Ruttenia dariensis, n. sp.					
Saracenaria moresiana	—	x	x	x	—
Siphonina tenuicarinata	x	—	—	—	—
Siphonodosaria puntensis, n. sp.					
Textularia hockleyensis var. *panamensis*, n. var.					
Textulariella barretti					
Tubinella jenningsi, n. sp.					
Uvigerina alata	—	x	x	x	x
Uvigerina boqueronensis, n. sp.					
Uvigerina spinulosa, n. sp.					
Vaginulina clarkeni, n. sp.					
Valvulineria cushmani, n. sp.					
Vulvulina spinosa	x	—	—	—	x

SYSTEMATIC DESCRIPTIONS

Family ASTRORHIZIDAE Brady, 1881

Genus PSAMMOSPHAERA Schultze, 1875

PSAMMOSPHAERA PARVA Flint

Plate 41, figure 1

Psammosphaera parva FLINT, *1899*, U. S. Nat. Mus., Rept. Recent Foraminifera, p. 268, pl. 9, fig. 1.

Test attached to sponge spicule which passes through the body of the test eccentrically; test entirely rough finished, composed of sand grains cemented together to form a globular-shaped mass; orifice not apparent but probably between sand grains.

Occurrence.—Upper Eocene to Recent; very rare in the Tranquilla shale, Panama.

Family MILIOLIDAE d'Orbigny, 1839

Genus CORNUSPIRA Schultze, 1854

CORNUSPIRA OLYGOGYRA Hantken
Plate 41, figure 15

Cornuspira olygogyra HANTKEN, *1875*, K. ungar. geol. Anst. Mitth. a. d. Jahrb., vol. 4, p. 20, pl. 1, fig. 10.—LIEBUS, *1906*, Geol. Reichanst. Jahrb., vol. 56, p. 360.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 15, pl. 4, fig. 14.

This species is rather common in the Tranquilla shale, occurring in almost every locality. Its close correspondence to Hantken's original description leaves no doubt as to its identity.

Occurrence.—Jackson Eocene of Mississippi; upper Eocene of Panama; upper Eocene and lower Oligocene (?) of Hungary.

Genus TUBINELLA Rhumbler, 1906

TUBINELLA JENNINGSI Coryell and Embich, n. sp.
Plate 41, figure 14

Test free, elongate; club-shaped and cylindrical in outline; initial chamber enlarged and occupying almost one-half the length of the test; only two chambers observed in a rectilinear sequence; wall calcareous, imperforate, and unornamented; aperture terminal, round, large, single. Length 0.7 mm.

Occurrence.—Rare in the Tranquilla shale, Panama. Columbia Univ. Coll., M39.

Family REOPHACIDAE Cushman, 1927

Genus REOPHAX Montfort, 1808

REOPHAX COLONENSIS Coryell and Embich, n. sp.
Plate 41, figures 2, 3

This species consists of two or three chambers, the flattened bulbous chamber cavities connected by short, thick necks; wall heavy and thick, composed of coarse, short pieces of sponge spicules; chambers in rectilinear series, rapidly enlarging; aperture terminal and somewhat produced by protruding sponge spicules. Length 1.35 mm.

Occurrence.—Fairly abundant in the Tranquilla shale, Panama. Columbia Univ. Coll., M40.

REOPHAX PARSONSENSIS Coryell and Embich, n. sp.
Plate 41, figure 4

Test composed of roughly fashioned globular chambers in a straight series; increasing rapidly in diameter as added; chambers appressed with no neck between; not labyrinthic; inside wall very coarsely arenaceous, composed of large white sand grains and pieces of broken sponge spicules; aperture single, terminal on the last septal face. Length 1.1 mm.

Occurrence.—Rather common in the Tranquilla shale, Panama. Columbia Univ. Coll., M41.

Family TROCHAMMINIDAE Schwager, 1877

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES DIBOLLENSIS Cushman and Applin
Plate 41, figure 5

Haplophragmoides dibollensis CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 163, pl. 6, figs. 1 *a*, *b*.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 6, pl. 1, figs. 1 *a*, *b*.

In this species the sponge spicules are arranged radially, spoke-like, from the depressed umbilical region.

Occurrence.—Caddell and McElroy of Texas; abundant in the upper Eocene Tranquilla shale, Panama.

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES HUMBOLDTI (Reuss)
Plate 41, figure 6

Spirolina humboldti REUSS, *1851*, Deutsche geol. Gesell., Zeitschr., vol. 3, p. 65, pl. 3, figs. 17, 18.
Haplophragmium humboldti (Reuss), HANTKEN, *1875*, K. ungar. geol. Anst., Mitth. a. d. Jahrb., vol. 4, p. 11, pl. 2, figs. 3, 4.
Ammobaculites humboldti (Reuss), CUSHMAN, *1910*, U. S. Nat. Mus., Bull. 71, pt. 1, p. 114, fig. 176.—NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 122, pl. 14, fig. 2.

These specimens appear to be rather coarser in texture than that figured from the Oligocene, and possess more chambers in the uncoiled portion.

Occurrence.—Upper Eocene of Venezuela and Panama; upper Eocene, lower and middle Oligocene of Europe; rather rare in the Tranquilla shale of Panama.

Genus AMMOMARGINULINA Wiesner, 1931

AMMOMARGINULINA TRANQUILLENSIS Coryell and Embich, n. sp.
Plate 41, figure 7

Test free, consisting of an early coiled portion and a later uncoiled portion with chambers arranged in a rectilinear series, the coiled portion consisting of seven or eight chambers; the uncoiled portion with several chambers of increasing width until the last one, which is narrower; chambers with labyrinthic walls, coarsely arenaceous, reinforced by sponge spicules arranged in a diagonal or transverse pattern; aperture on the last septal face, round, terminal. Length 1.23 mm.

Occurrence.—Very common in the upper Eocene Tranquilla shale, Panama. Columbia Univ. Coll., M42.

Family ATAXOPHRAGMIIDAE Schwager, 1877

Genus HETEROSTOMELLA Reuss, 1866

HETEROSTOMELLA sp.
Plate 41, figure 10

Test elongate, early chambers coiled into a high spire occupying approximately one-fifth or one-sixth the length of the test. This portion of the test is triserial with rather indistinct sutures; the remainder of the test triserial with sutures deep and furrow-like, becoming almost ridge-shaped near the median

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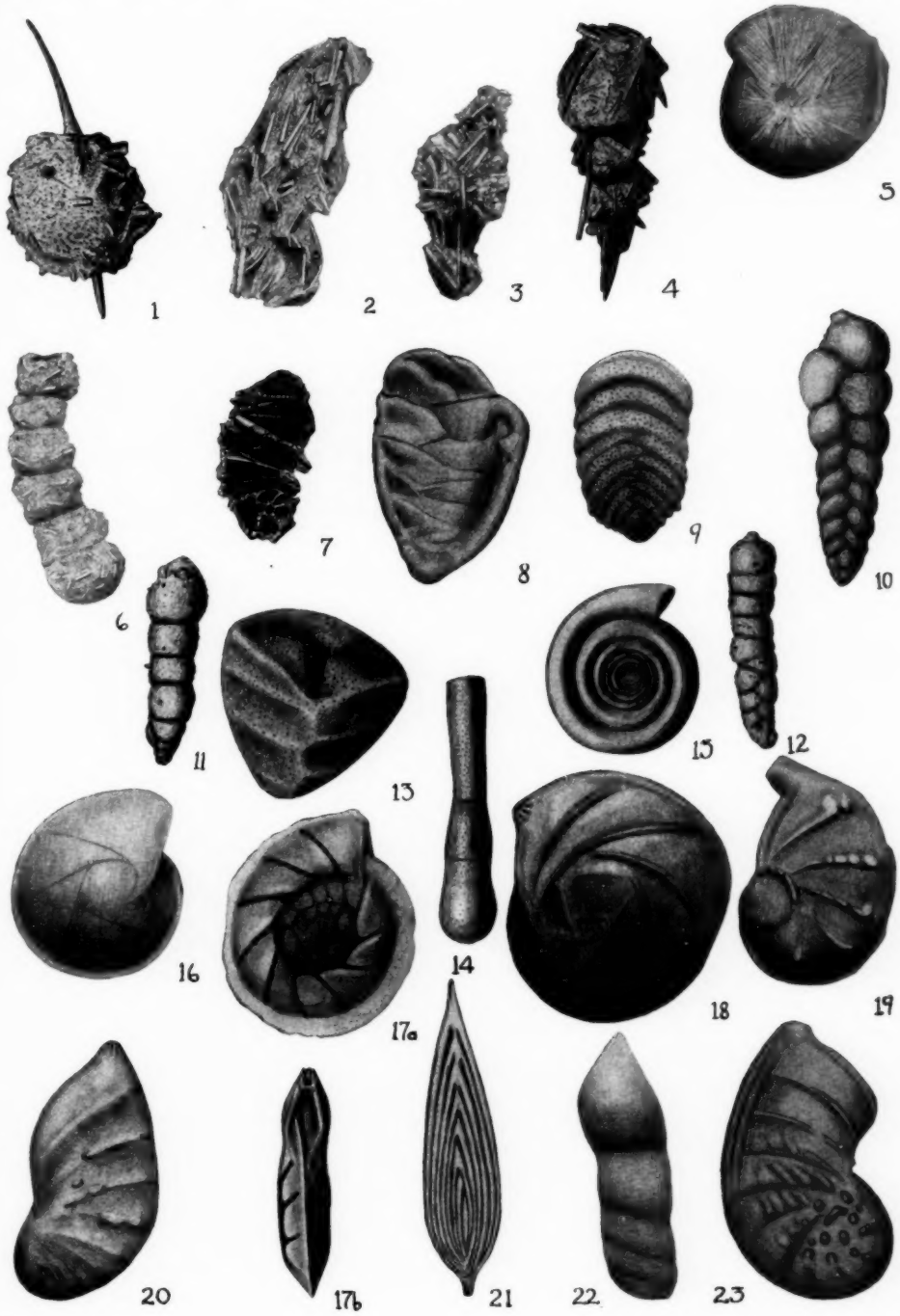
EXPLANATION OF PLATE 41

All specimens figured are from the Tranquilla shale, Panama.
All specimens are deposited in the Columbia University Micropaleontological Collection.

FIGS. *1*—*Psammosphaera parva* Flint, ×97. (p. 292)
2, 3—*Reophax colonensis* Coryell and Embich, n. sp., ×34. (p. 293)
4—*Reophax parsonsensis* Coryell and Embich, n. sp., ×36. (p. 293)
5—*Haplophragmoides dibollensis* Cushman and Applin, ×37. (p. 293)
6—*Ammobaculites humboldti* (Reuss), ×38. (p. 294)
7—*Ammomarginulina tranquillensis* Coryell and Embich, n. sp., ×20. (p. 294)
8—*Textularia hockleyensis* var. *panamensis* Coryell and Embich, n. var., ×35. (p. 295)
9—*Vulvulina spinosa* Cushman, ×29. (p. 295)
10—*Heterostomella* sp., ×28. (p. 294)
11—*Liebusella baylesi* Coryell and Embich, n. sp., ×35. (p. 295)
12—*Listerella anconensis* Coryell and Embich, n. sp., ×38. (p. 295)
13—*Textulariella barretti* (Jones and Parker), ×62. (p. 295)
14—*Tubinella jenningsi* Coryell and Embich, n. sp., ×51. (p. 293)
15—*Cornuspira olygogyra* Hantken, ×48. (p. 293)
16—*Robulus alato-limbatus* (Gümbel), ×27. (p. 299)
17a, b—*Robulus terryi* Coryell and Embich, n. sp., ×32. (p. 299)
18—*Robulus arcuato-striatus* var. *carolinianus* Cushman, ×28. (p. 299)
19—*Planularia thalmanni* (Pijpers), ×58. (p. 297)
20—*Vaginulina clarkeni* Coryell and Embich, n. sp., ×27. (p. 296)
21—*Frondicularia tenuissima* Hantken, ×29. (p. 296)
22—*Marginulina alazanensis* Nuttall, ×30. (p. 297)
23—*Marginulina fragaria* var. *texasensis* (Cushman and Applin), ×29. (p. 297)



Coryell and Embich, Eocene Foraminifera

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line of the test; wall arenaceous and smooth; aperture at the center of the last chamber, terminal, round, at the end of a short, thick neck.

Occurrence.—Very rare in the Tranquilla shale, Panama.

Genus LIEBUSELLA
Cushman, 1933

LIEBUSELLA BAYLESI Coryell and Embich, n. sp.
Plate 41, figure 11

Test free, chambers arranged in three series, initial series with four or five chambers to the whorl, rapidly dropping to four, then to three, and in the final series uniserial, arranged in rectilinear form; wall coarsely arenaceous but well finished; aperture consisting of from three to five subdivisions arranged in a somewhat radial fashion. Length 0.81 mm.

Occurrence.—Rare in the Tranquilla shale, Panama. Columbia Univ. Coll., M43.

Genus LISTERELLA
Cushman, 1933

LISTERELLA ANCONENSIS Coryell and Embich, n. sp.
Plate 41, figure 12

Test free, consisting of three stages; first stage a five-chambered whorl occupying about one-fourth the length of the test, followed by three and then two chambers; the last or adult stage having uniserial chambers arranged in rectilinear fashion; wall finely arenaceous; aperture terminal with a slender neck. Length 0.85 mm.

Occurrence.—Rather rare in the Tranquilla shale, Panama. Columbia Univ. Coll., M44.

Family TEXTULARIIDAE
d'Orbigny, 1846

Genus TEXTULARIA
de France, 1824

TEXTULARIA HOCKLEYENSIS var. PANAMENSIS Coryell and Embich, n. var.
Plate 41, figure 8

Test broadly oval in outline, truncated at the apertural end. This variety is broader at the median portion than *T. hockleyensis* Cushman and Applin. Length 0.9 mm.

We are of the opinion that this variety occurs in a horizon similar to the *T. hockleyensis* zone of the Gulf Coast.

Occurrence.—*T. hockleyensis* occurs in the McElroy and Caddell of Texas; upper Eocene of Atlantic and Gulf coasts. The new variety occurs in the Tranquilla shale of Panama. Columbia Univ. Coll., M54.

Genus TEXTULARIELLA
Cushman, 1927

TEXTULARIELLA BARRETTI (Jones and Parker)
Plate 41, figure 13

Textularia barretti JONES and PARKER, *1863*, British Assoc., Rept., pp. 80, 105; *1876*, Soc. Malacol. Belg., Ann., vol. 11, p. 99.
Textulariella barretti (Jones and Parker) CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 24, pl. 5, fig. 3.
Textularia conica GÖES (not d'Orbigny), *1896*, Harvard Coll. Mus. Comp. Zoology, Bull., vol. 29, p. 43.

Occurrence.—Very rare in the Tranquilla shale, Panama; upper Eocene to Recent.

Genus VULVULINA d'Orbigny, 1826

VULVULINA SPINOSA Cushman
Plate 41, figure 9

Vulvulina spinosa CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 111, pl. 23, fig. 1; *1927*, Jour. Paleontology, vol. 1, p. 149, pl. 28, fig. 4.—NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 123, pl. 14, fig. 6.

This species is found in the lower Oligocene, Alazan, of Mexico and Panama. It is abundant in the upper Eocene of Panama, occurring at nearly all the outcrops of the Tranquilla shale.

Occurrence.—Upper Eocene and Oligocene.

Family NODOSARIIDAE
Schultze, 1854

Genus SARACENARIA
de France, 1824

SARACENARIA MORESIANA Howe and Wallace
Plate 42, figure 3

Saracenaria moresiana HOWE and WALLACE, *1932*, Louisiana Dept. Cons., Geol. Bull. 2, p. 42, pl. 2, figs. 8 *a–c*.

Occurrence.—Upper and lower Jackson, Louisiana; abundant upper Eocene, Panama.

Genus ASTACOLUS Montfort, 1808

ASTACOLUS sp.
Plate 42, figure 4

Early portion of test planispiral, consisting of almost a complete revolution; the remainder, about four-fifths of the test, uncoiled; outer margin of the later chambers reaching nearly back to the involute portion of the test; surface smooth; periphery usually without carinae; wall very finely perforated; aperture terminal, at outer end of the last chamber, round, radiate.

Occurrence.—Rare in the Tranquilla shale, Panama.

Genus FRONDICULARIA de France, 1826

FRONDICULARIA TENUISSIMA Hantken
Plate 41, figure 21

Frondicularia tenuissima HANTKEN, *1875*, K. ungar. geol. Anst., Mitth. a. d. Jahrb., vol. 4, p. 43, pl. 13, fig. 11.—CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 111, pl. 22, fig. 11.—NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 125, pl. 14, fig. 21.

Characteristic forms of this species occur in the upper Eocene of the Chagres River Basin.

Occurrence.—Upper Eocene, Venezuela and Panama; upper Eocene and lower Oligocene, Europe.

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA CLARKENI Coryell and Embich, n. sp.
Plate 41, figure 20

Test free, elongate, partially coiled at initial end; coil not making one complete

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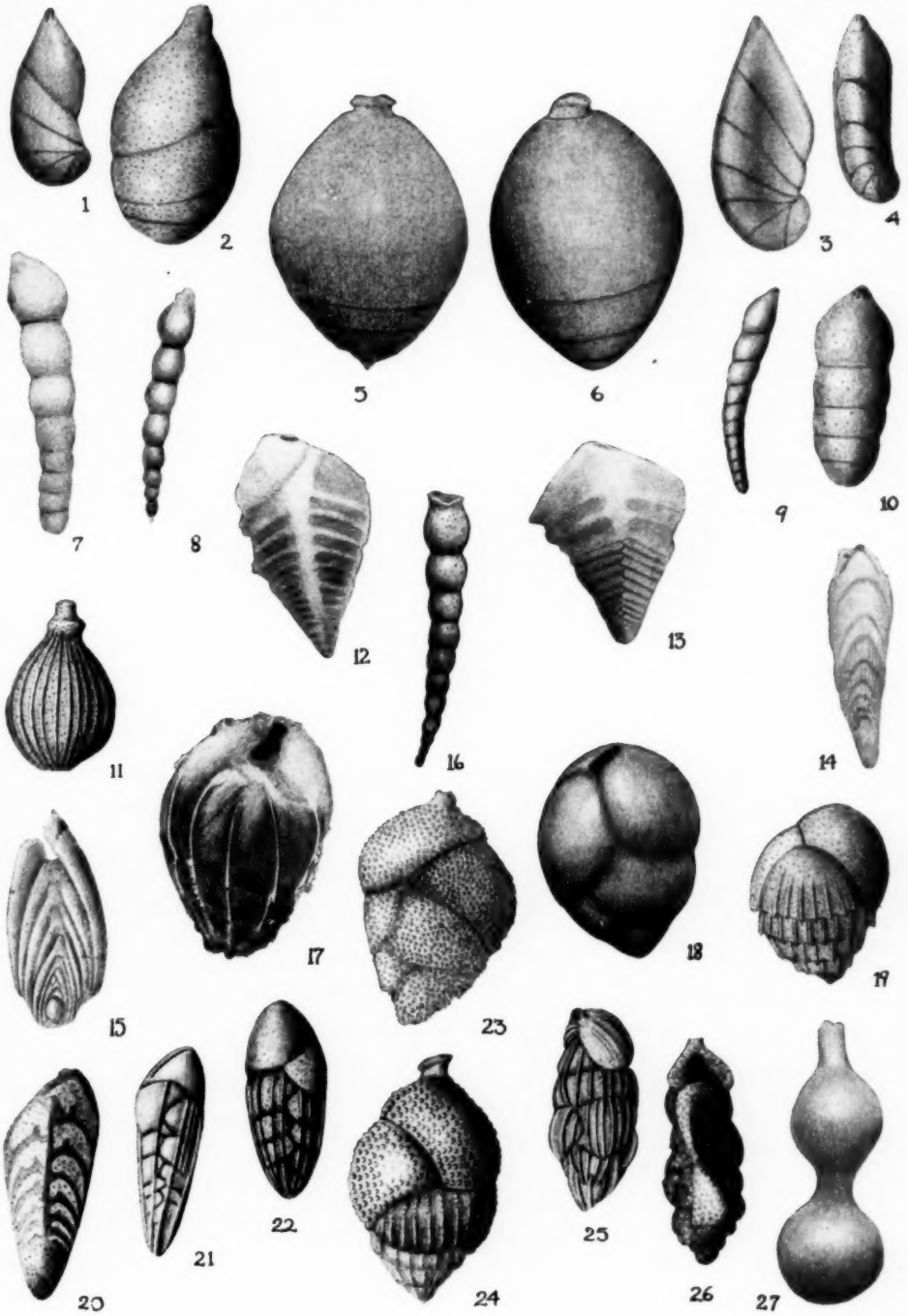
EXPLANATION OF PLATE 42

All specimens figured are from the Tranquilla shale, Panama.
All specimens are deposited in the Columbia University Micropaleontological Collection.

FIGS. *1*—*Marginulina triangularis* var. *panamensis* Coryell and Embich, n. var., ×34. (p. 297)
2—*Marginulina subbullata* Hantken, ×58. (p. 297)
3—*Saracenaria moresiana* Howe and Wallace, ×30. (p. 296)
4—*Astacolus* sp., ×37. (p. 296)
5—*Lagenoglandulina subovata* var. *chagresensis* Coryell and Embich, n. var., ×66. (p. 298)
6—*Lagenoglandulina napaeformis* (Stache), ×61. (p. 298)
7—*Dentalina cooperensis* Cushman, ×30. (p. 298)
8—*Dentalina jacksonensis* (Cushman and Applin), ×38. (p. 298)
9—*Dentalina consobrina* var. *emaciata* (Reuss), ×22. (p. 298)
10—*Nodosaria radicula* (Linnaeus), ×48. (p. 298)
11—*Lagena costata* (Williamson), ×80. (p. 299)
12, 13—*Bolivinoides planulis* Coryell and Embich, n. sp., ×35. (p. 303)
14—*Plectofrondicularia cookei* Cushman, ×38. (p. 303)
15—*Plectofrondicularia vaughani* Cushman, ×38. (p. 303)
16—*Nodogenerina cooperensis* Cushman, ×35. (p. 303)
17—*Bulimina jacksonensis* Cushman, ×65. (p. 304)
18—*Bulimina pyrula* d'Orbigny, ×34. (p. 304)
19—*Bulimina inflata* Seguenza, ×60. (p. 304)
20—*Bolivina malkinae* Coryell and Embich, n. sp., ×64. (p. 302)
21—*Bolivina tranquilla* Coryell and Embich, n. sp., ×62. (p. 303)
22—*Loxostoma dalli* (Cushman), ×80. (p. 303)
23—*Uvigerina spinulosa* Coryell and Embich, n. sp., ×71. (p. 304)
24—*Uvigerina boqueronensis* Coryell and Embich, n. sp., ×80. (p. 304)
25—*Uvigerina alata* Cushman and Applin, ×45. (p. 304)
26—*Angulogerina sanjuanensis* Coryell and Embich, n. sp., ×100. (p. 305)
27—*Siphonodosaria puntensis* Coryell and Embich, n. sp., ×61. (p. 305)



Coryell and Embich, Eocene Foraminifera

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volution; edges angled and almost carinate on outer edge; chambers numerous, closely appressed; sutures slightly oblique, limbate, and raised, the raised portion being most conspicuous on the median portion of the test; wall hyaline, finely perforate, smooth; aperture marginal, raised, radiate. Length 1.35 mm.

Remarks.—This species resembles *Vaginulina elegans* from the Alazan shale as described by Nuttall. It differs in the general proportions of the chambers and the character of the initial coil.

The species is named for Dr. John Clarken of Panama.

Occurrence.—Rather rare in Tranquilla shale, Panama. Columbia Univ. Coll., M46.

Genus PLANULARIA de France, 1824

PLANULARIA THALMANNI (Pijpers) Plate 41, figure 19

Cristellaria (*Planularia*) *thalmanni* PIJPERS, *1933*, Geol. Pal. Bonaire, p. 60, figs. 27–30.
Planularia thalmanni (Pijpers), NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 124, pl. 14, fig. 15.

Our specimens vary somewhat from the type of this species, but the variation is not considered sufficient to establish a new variety.

Occurrence.—Upper Eocene, Venezuela; quite rare in the Tranquilla shale, Panama.

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA ALAZANENSIS Nuttall Plate 41, figure 22

Marginulina alazanensis NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 13, pl. 3, figs. 3, 7.

The specimens from the upper Eocene of Panama are somewhat shorter and heavier than those from the Alazan of Mexico.

Occurrence.—Quite common in the Tranquilla shale, Panama; Alazan, Mexico.

MARGINULINA FRAGARIA var. TEXASENSIS (Cushman and Applin) Plate 41, figure 23

Cristellaria fragaria var. *texasensis* CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 171, pl. 8, figs. 5–7.
Lenticulina fragaria var. *texasensis* (Cushman and Applin), HOWE and WALLACE, *1932*, Louisiana Dept. Cons., Geol. Bull. 2, p. 32, pl. 5, figs. 3–5.
Marginulina fragaria var. *texasensis* (Cushman and Applin), ELLISOR, *1933*, Am. Assoc. Petroleum Geologists, Bull., vol. 17, p. 1336, pl. 2, fig. 4.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 19, pl. 7, figs. 8–10.

Occurrence.—Upper Eocene, Jackson, of Alabama, Louisiana; rather rare in the Tranquilla shale, Panama.

MARGINULINA TRIANGULARIS var. PANAMENSIS Coryell and Embich, n. var. Plate 42, figure 1

Test large, elongate, the cross section of the test resembling a triangle. The early portion coiled, the later portions uncoiled; seven chambers usually visible, those in the uncoiled portion enlarging rapidly; sutures in uncoiled portion rather indistinct, not depressed; wall calcareous; aperture radiate. Length 0.7 mm.

Remarks.—This variety of d'Orbigny's species is more similar to d'Orbigny's illustrations than to the specimens described by Howe and Wallace. It seems, however, to be a new variety of d'Orbigny's species.

Occurrence.—*M. triangularis* occurs in the upper Jackson, Louisiana; *M. triangularis* var. *panamensis* occurs in the upper Eocene, Panama. Columbia Univ. Coll., M47.

MARGINULINA SUBBULLATA Hantken Plate 42, figure 2

Marginulina subbullata HANTKEN, *1875*, K. ungar. geol. Anst., Mitth. a. d. Jahrb., vol. 4, p. 46, pl. 4, figs. 9, 10; pl. 5, fig. 9.—CUSHMAN, *1925*, Cushman Lab. Foram. Research, Contr., vol. 1, p. 62, pl. 10, fig. 3.—NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 125, pl. 14, fig. 16.

Occurrence.—Upper Eocene, Venezuela; moderately common in Tranquilla shale, Panama; upper Eocene, Mexico; upper Eocene and lower Oligocene (?) of Europe.

Genus LAGENOGLANDULINA Sylvestri, 1923

LAGENOGLANDULINA NAPAEFORMIS (Stache) Plate 42, figure 6

Glandulina napaeformis STACHE, *1864*, Novara Exped., vol. 1, pt. 2, p. 186, pl. 22, fig. 8.

Test free, chambers in a rectilinear series, apertural chamber embracing fully two-thirds of test; three initial chambers always visible, which distinguish this species from *L. subovata*. Aperture terminal, produced, round; apertural neck set in a depression, thick, heavy. Wall smooth, calcareous, finely perforate.

Occurrence.—This species was found by Stache in the Middle Tertiary. Species of *Lagenoglandulina* have not been found in Central America previous to this record from the upper Eocene of Panama.

LAGENOGLANDULINA SUBOVATA var. CHAGRESENSIS Coryell and Embich, n. var. Plate 42, figure 5

Test free; chambers in a rectilinear series or final chamber almost or completely embracing early chambers; initial end sometimes with a spine; outer chamber expands rapidly to the maximum diameter of the test, which is approximately the middle. From the area of maximum diameter the test curves gently to the anterior portion where the neck of the apertural end is set in a depression. The aperture is terminal, produced, round, with crenulate edge. Wall is calcareous, thick, finely perforate. Length 0.6 mm.

Occurrence.—Abundant, Tranquilla shale, Panama. Columbia Univ. Coll., M48.

Genus DENTALINA d'Orbigny, 1839

DENTALINA COOPERENSIS Cushman Plate 42, figure 7

Dentalina cooperensis CUSHMAN, *1933*, Cushman Lab. Foram. Research, Contr., vol. 9, p. 8, pl. 1, fig. 17; *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 20, pl. 8, figs. 3, 4.

Occurrence.—Upper Eocene, Cooper marl, South Carolina; upper Eocene Tranquilla shale, Panama.

DENTALINA CONSOBRINA var. EMACIATA Reuss Plate 42, figure 9

Dentalina emaciata REUSS *1851*, Deutsche geol. Gesell., Zeitschr., vol. 3, p. 63, pl. 3, fig. 9.

Nodosaria (Dentalina) consobrina var. *emaciata* REUSS, *1865*, K. Akad. Wiss. Wien., Denkschr., vol. 25, p. 132, pl. 2, figs. 12, 13.

Dentalina consobrina emaciata Reuss, HOWE and WALLACE, *1932*, Louisiana Dept. Cons., Geol. Bull. 2, p. 25, pl. 7, fig. 7.

Occurrence.—Upper Jackson, Louisiana; upper Oligocene to Recent of Europe; common in Tranquilla shale, Panama.

DENTALINA JACKSONENSIS (Cushman and Applin) Plate 42, figure 8

Nodosaria jacksonensis CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 170, pl. 7, figs. 14–16.—CUSHMAN, *1927*, Jour. Paleontology, vol. 1, p. 153, pl. 24, fig. 3.—COLE, *1928*, Bull. Am. Paleontology, vol. 14, no. 53, p. 208, pl. 3, fig. 12.

Dentalina jacksonensis (Cushman and Applin), CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 20, pl. 8, figs. 7–9.

This form is the most abundant species of *Dentalina* in the Tranquilla shale of Panama.

Occurrence.—Upper Eocene.

Genus NODOSARIA Lamarck, 1812

NODOSARIA RADICULA (Linnaeus) Plate 42, figure 10

Nautilus radicula LINNAEUS, *1767*, Syst. Nat., 12th ed., pp. 285, 1164, 1788; 13th ed., vol. 1, pt. 6, p. 3373, no. 18.

Nodosaria radicula (Linnaeus), D'ORBIGNY, *1826*, Annaes sci. nat., vol. 7, p. 252, no. 3; Model 1.—CUSHMAN, *1919*, U. S. Nat. Mus., Bull. 100, vol. 4, p. 190, pl. 34, fig. 4.—PLUMMER, *1926*, Texas Univ., Bull. 2644, p. 77, pl. 4, figs. 9 *a*, *b*.

There is considerable range of form in this species. The variation is due to the marked constriction of sutures in some individuals and scarcely any constrictions in others. On some specimens the area of non-constricted sutures, characteristic of the initial end, extends to the apertural end.

Occurrence.—Triassic to Recent; specimens characteristic of the species abundant in the Tranquilla shale of Panama.

Genus LAGENA Walker and Boys, 1784

LAGENA COSTATA (Williamson)
Plate 42, figure 11

Entosolenia costata WILLIAMSON, *1858*, Recent Foram. Great Britain, p. 9, pl. 1, fig. 18.
Lagena costata (Williamson), REUSS, *1862*, K. Akad. Wiss. Wien, Sitzungsber., vol. 46, p. 329, pl. 4, fig. 54.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 23, pl. 9, figs. 7, 8.

Test subglobular, tapering gradually to the neck; wall ornamented with 16 or 17 rib-like costae; neck can be divided into a thickened portion near the base and a thinner more pointed area near the aperture; aperture simple, raised, terminal.

This beautiful *Lagena* is found rarely in the upper Eocene shales of Panama.

Occurrence.—Cretaceous, upper Eocene, and Recent.

Genus ROBULUS Montfort, 1808

ROBULUS ALATO-LIMBATUS (Gümbel)
Plate 41, figure 16

Robulina alato-limbata GÜMBEL, *1868* (1870), K. bayer. Akad. Wiss., Math.-Phys., Classe II, vol. 10, p. 641, pl. 2, figs. 70 *a*, *b*.
Cristellaria alato-limbata (Gümbel), CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 171, pl. 8, fig. 8.
Robulus alato-limbatus (Gümbel), CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 15, pl. 6, figs. 2 *a*, *b*.
Robulus alato-limbata (Gümbel), HOWE and WALLACE, *1932*, Louisiana Dept. Cons., Geol. Bull. 2, p. 37, pl. 3, figs. 2 *a*, *b*.

Occurrence.—Upper Eocene, Louisiana, Panama, etc.

ROBULUS ARCUATO-STRIATUS var. CAROLINIANUS Cushman
Plate 41, figure 18

Robulus arcuato-striatus (Hantken) var. *carolinianus* CUSHMAN, *1933*, Cushman Lab. Foram. Research, Contr., vol. 9, p. 4, figs. 9, *a*, *b*; *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 17, pl. 6, figs. 6 *a*, *b*.

Occurrence.—Upper Eocene; fairly common in Tranquilla shale, Panama.

ROBULUS TERRYI Coryell and Embich, n. sp.
Plate 41, figures 17*a*, *b*

Test free, close-coiled, with a wide carina; chambers 12 or 14 in number becoming narrower toward the umbilical area of the test; due to shortening, the chambers fail to cover preceding whorl entirely; sutures limbate, but not raised; slightly curved; orifice robuline on the last septal face. Diameter, 1.02 mm.

This species was named for Mr. Robert Terry.

Occurrence.—Rare in the Tranquilla shale, Panama. Columbia Univ. Coll., M49.

Family NONIONIDAE Reuss, 1860

Genus HANTKENINA Cushman, 1925

HANTKENINA ALABAMENSIS Cushman
Plate 43, figure 10

Hantkenina alabamensis CUSHMAN, *1925*, U. S. Nat. Mus., Proc., vol. 66, art. 30, p. 3, pl. 1, figs. 1–6; pl. 2, fig. 5.—CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 177, pl. 10, fig. 3.—HOWE and WALLACE, *1932*, Louisiana Dept. Cons., Geol. Bull. 2, p. 54, pl. 10, fig. 3.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 49, pl. 13, figs. 1–5.

This species of *Hantkenina* is characteristic in the upper Eocene and has also been found in the lower Oligocene of Mississippi and in the Alazan clay of

Mexico; it was not found in the Alazan of Panama, but was very abundant in the Tranquilla shales.

Occurrence.—Upper Eocene (common); lower Oligocene (rare).

Family ROTALIIDAE Reuss, 1860

Genus LAMARCKINA Berthelin, 1881

LAMARCKINA CURRYI Coryell and Embich, n. sp.
Plate 43, figure 1

Test rotaline, the early chambers visible on the dorsal side, slightly more convex on the dorsal side than on the ventral; chambers eight or nine in number, hyaline, and coarsely perforate; chambers enlarge rapidly, the final one occupying more than one-half of the area of the test. Diameter 0.4 mm.

Occurrence.—Rare, Tranquilla shale, Panama. Columbia Univ. Coll., M62.

LAMARCKINA HISPIDA Coryell and Embich, n. sp.
Plate 43, figure 2

Test free, rotaloid, early chambers forming one complete whorl visible on the dorsal side of the test; this initial whorl is flattened; the last chamber makes up a considerable portion of the test, constituting one-third of the last whorl; all whorls except the last coarsely spinose; spines bifurcating; aperture opens into the umbilicus. Diameter, 0.35 mm.

Occurrence.—Common, Tranquilla shale, Panama. Columbia Univ. Coll., M50.

Genus VALVULINERIA Cushman, 1926

VALVULINERIA CUSHMANI Coryell and Embich, n. sp.
Plate 43, figure 3

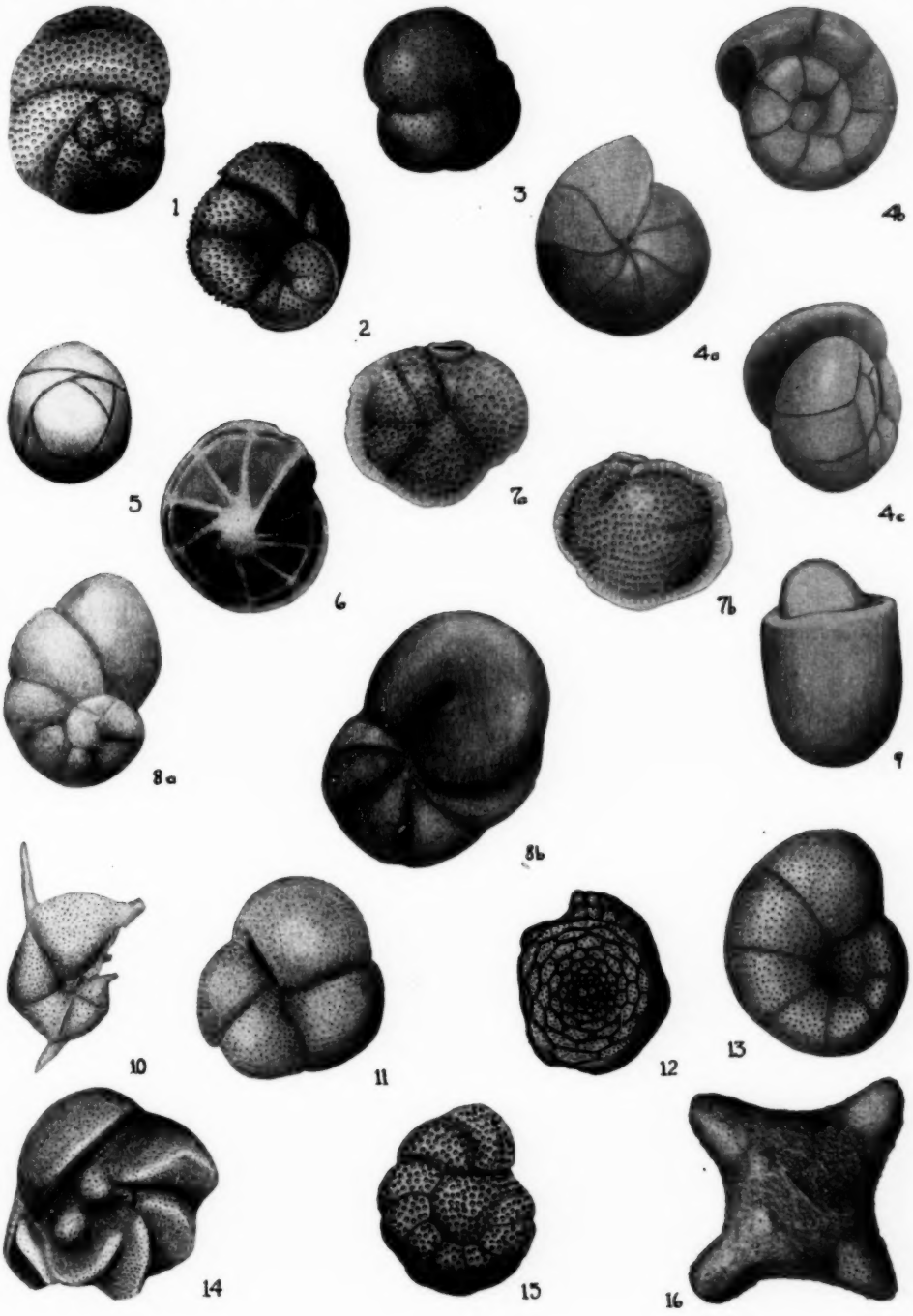
Test rotaloid, all chambers visible on the dorsal side, involute on the ventral; periphery rounded; chambers five to six, increasing rapidly in size to the last, which is bulbous, occupying almost one-half the test and extending into the umbilicus; the extension resembles a narrow lip not covering the umbilicus, which is partly open; the outer four or five chambers occupy the remaining portion of the volution; on the ventral side they form denticulations pointing into the umbilicus; wall hyaline, coarsely perforate; aperture a curved slit at the base of the last septal face on the ventral side near the umbilicus. Diameter, 0.65 mm.

Occurrence.—Tranquilla shale, Panama. Columbia Univ. Coll., M51.

EXPLANATION OF PLATE 43

All specimens figured are from the Tranquilla shale, Panama.
All specimens are deposited in the Columbia University Micropaleontological Collection.

FIGS. *1—Lamarckina curryi* Coryell and Embich, n. sp., ×70. (p. 300)
2—Lamarckina hispida Coryell and Embich, n. sp., ×68. (p. 300)
3—Valvulineria cushmani Coryell and Embich, n. sp., ×37. (p. 300)
4a-c—Gyroidina guayabalensis Cole, ×70. (p. 301)
5—Eponides jacksonensis (Cushman and Applin), ×33. (p. 301)
6—Epistomina elegans (d'Orbigny), ×39. (p. 301)
7a, b—Siphonina tenuicarinata Cushman, ×34. (p. 301)
8a, b—Ceratobulimina alazanensis Cushman and Harris, ×80. (p. 302)
9—Chilostomella grandis Cushman, ×40. (p. 302)
10—Hantkenina alabamensis Cushman, ×37. (p. 299)
11—Globorotalia cocoaensis Cushman, ×36. (p. 301)
12—Cycloloculina annulata Heron-Allen and Earland, ×48. (p. 301)
13—Anomalina pacoraensis Coryell and Embich, n. sp., ×71. (p. 301)
14—Ruttenia dariensis Coryell and Embich, n. sp., ×140. (p. 302)
15—Cibicides pseudoungerianus (Cushman), ×32. (p. 302)
16—Asterocyclina gamboaensis Coryell and Embich, n. sp., ×115. (p. 305)



Coryell and Embich, Eocene Foraminifera

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA GUAYABALENSIS Cole

Plate 43, figures 4*a–c*

Gyroidina guayabalensis COLE, *1927*, Bull. Am. Paleontology, no. 51, p. 28, pl. 2, figs. 25–27.

Occurrence.—Upper Eocene; very abundant in the Tranquilla shale, Panama.

Genus EPONIDES Montfort, 1808

EPONIDES JACKSONENSIS (Cushman and Applin)

Plate 43, figure 5

Pulvinulina jacksonensis CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 181, pl. 9, figs. 24, 25.
Eponides jacksonensis (Cushman and Applin), CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 46, pl. 19, figs. 4–8.

This species somewhat resembles *Eponides mexicanus* Cushman.

Occurrence.—Upper Eocene; very common at all localities of the upper Eocene of Panama.

Genus EPISTOMINA Terquem, 1883

EPISTOMINA ELEGANS (d'Orbigny)

Plate 43, figure 6

Nautili ammoniformis sive trochiformis SOLDANI, *1798*, Testac. 2, App., pl. 2, fig. R.
Rotalia (*Turbinulina*) *elegans* D'ORBIGNY, *1826*, Annaes sci. nat., vol. 7, p. 276, no. 54.
Epistomina elegans (d'Orbigny), CUSHMAN, *1931*, U. S. Nat. Mus., Bull. 104, p. 65, pl. 13, figs. 6 *a–c*.—HOWE and WALLACE, *1932*, Louisiana Dept. Cons., Geol. Bull. 2, p. 68, pl. 13, fig. 2.

Cushman's work listed above may be consulted for the voluminous references to this species.

Occurrence.—Jurassic to Recent; rare in the Tranquilla shale, Panama.

Genus SIPHONINA Reuss, 1850

SIPHONINA TENUICARINATA Cushman

Plate 43, figures 7*a*, *b*

Siphonina tenuicarinata CUSHMAN, *1927*, Jour. Paleontology, vol. 1, p. 166, pl. 26, figs. 11, 12.

Occurrence.—Upper Eocene, Tranquilla shale, Panama; rare lower Oligocene, Panama; lower Oligocene Alazan, Mexico.

Family GLOBOROTALIIDAE Cushman, 1927

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA COCOAENSIS Cushman

Plate 43, figure 11

Globorotalia cocoaensis CUSHMAN, *1928*, Cushman Lab. Foram. Research, Contr., vol. 4, p. 75, pl. 10, figs. 3 *a–c*.—HOWE and WALLACE, *1932*, Louisiana Dept. Cons., Geol. Bull. 2, p. 75, pl. 14, fig. 4.—ELLISOR, *1933*, Am. Assoc. Petroleum Geologists, Bull., vol. 17, no. 11, pl. 4, figs. 6 *a*, *b*.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 50, pl. 21, figs. 1–3.

Occurrence.—Upper Eocene; rather rare in the outcrops of Tranquilla shale of Panama.

Genus CYCLOLOCULINA Heron-Allen and Earland, 1908

CYCLOLOCULINA ANNULATA Heron-Allen and Earland

Plate 43, figure 12

Cycloloculina annulata HERON-ALLEN and EARLAND, *1908*, Royal Micr. Soc., Jour., p. 536, pl. 12, figs. 1–7.

Occurrence.—Tertiary; common in the Tranquilla shale of Panama.

Family ANOMALINIDAE Cushman, 1927

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA PACORAENSIS Coryell and Embich, n. sp.

Plate 43, figure 13

Test free, coiled, embracing on apertural side, almost embracing on dorsal side; chambers six to eight, not much inflated, broader than high; wall hyaline, coarsely punctate; aperture a slit at the base of the septum extending from the umbilicus to the periphery. This *Nonion*-like *Anomalina* is characterized by the aperture running into the umbilicus, by

the deep umbilical area, and flattened chambers. Diameter 0.45 mm.

Occurrence.—Abundant, Tranquilla shale, Panama. Columbia Univ. Coll., M52.

Genus RUTTENIA Pijpers, 1933

RUTTENIA DARIENSIS Coryell and Embich, n. sp.
Plate 43, figure 14

Test free, rotaline, not compressed; dorsal side concave, ventral side flat; chambers very distinct and sutures lying in depressed areas between the chambers, giving a turbinate effect; the spire of the early volution occupies the bottom of a shallow depression on the dorsal face; wall hyaline, finely perforate; aperture a narrow slit on the periphery. Diameter, 0.23 mm.

Occurrence.—Rare, upper Eocene Tranquilla shale, Panama. Columbia Univ. Coll., M53.

Genus CIBICIDES Montfort, 1808

CIBICIDES PSEUDOUNGERIANUS (Cushman)
Plate 43, figure 15

Truncatulina ungeriana H. B. BRADY, *1884*, Challenger Rept., Zoology, vol. 9, pl. 94, figs. 9 *a–c* (not *Rotalina ungeriana* d'Orbigny).

Truncatulina pseudoungeriana CUSHMAN, *1922*, U. S. Geol. Survey, Prof. Paper 129, pp. 97, 136, pl. 20, fig. 9; *1923*, U. S. Geol. Survey, Prof. Paper 133, p. 40.

Cibicides pseudoungerianus (Cushman), COLE and GILLESPIE, *1930*, Bull. Am. Paleontology, vol. 15, no. 57B, p. 15, pl. 3, figs. 10, 11.—ELLISOR, *1933*, Am. Assoc. Petroleum Geologists, Bull., vol. 17, no. 11, pl. 5, figs. 3, 4.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 52, pl. 23, figs. 1 *a–c*.

Occurrence.—Eocene to Recent; very abundant in Tranquilla shale, Panama.

Genus CERATOBULIMINA Toula, 1915

CERATOBULIMINA ALAZANENSIS Cushman and Harris
Plate 43, figures 8*a*, *b*

Ceratobulimina alazanensis CUSHMAN and HARRIS, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 174, pl. 29, figs. 5 *a–c*; pl. 30, figs. 3–5.

The holotype is from the Alazan clay, but the species occurs abundantly in the Tranquilla shale and is very characteristic of the upper Eocene localities in the Chagres Valley.

Occurrence.—Upper Eocene and lower Oligocene.

Family CHILOSTOMELLIDAE Brady, 1881

Genus CHILOSTOMELLA Reuss, 1850

CHILOSTOMELLA GRANDIS Cushman
Plate 43, figure 9

Chilostomella grandis CUSHMAN, *1917*, U. S. Nat. Mus., Proc., vol. 51, p. 662; *1921*, U. S. Nat. Mus., Bull. 100, pt. 4, p. 283, pl. 57, figs. 5 *a–c*; *1930*, Cushman Lab. Foram. Research, Contr., vol. 6, p. 61, pl. 8, fig. 14.

Cushman notes that this species has a very heavy test and is evidently a bottom-living species. The species has been found in recent dredgings on the coast of Australia.

Occurrence.—Upper Eocene to Recent; abundant in the Tranquilla shale, Panama.

Family HETEROHELICIDAE Cushman, 1927

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA MALKINAE Coryell and Embich, n. sp.
Plate 42, figure 20

Test free, compressed, widening gradually from a blunt initial end to the apertural end; the boundary of the shell is edged with clear shell material, making it appear somewhat carinated; the test consists of from seven to nine chambers; sutures oblique, extending from a raised central portion to the periphery; sutures on one lateral view are depressed with the chamber cavities lobulate in outline; on the other lateral half of the test, the sutures are bilobed; wall hyaline, perforate; aperture a comma-shaped opening at the intersection of the last cham-

ber with the preceding one. Length 0.5 mm.

Occurrence.—Rare, Tranquilla shale, Panama. Columbia Univ. Coll., M54.

BOLIVINA TRANQUILLA Coryell and Embich, n. sp.
Plate 42, figure 21

Test free, flattened, elongate; somewhat twisted biserial chambers with inner edges of chambers forming a series of salient and re-entrant angles; outer margin rounded with eight to ten rib-like ornamentations, extending from the initial end of the test toward the apertural end; wall hyaline, finely perforate; aperture at the base of the last chamber. Length 0.45 mm.

Occurrence.—Fairly common in the Tranquilla shale, Panama. Columbia Univ. Coll., M55.

Genus BOLIVINOIDES Cushman, 1927

BOLIVINOIDES PLANULIS Coryell and Embich, n. sp.
Plate 42, figures 12, 13

Test free, lance-shaped, thickest in the middle, sloping evenly to the periphery which is entire; chamber walls between the sutures wider than intervening spaces; chambers biserial, shortening regularly so that the test ends sharply; number of chambers 12 to 18. Greatest thickness, as well as greatest width of the test, at about the third chamber from the apertural end; aperture single, terminal, a wide fissure in the face of the last chamber. Length 0.9 mm.

Remarks.—This is undoubtedly closely related to the species *Proroporus mexicanus* Cole, which is evidently a *Bolivinoides*.

Occurence.—Tranquilla shale, Panama. Columbia Univ. Coll., M56.

Genus LOXOSTOMA Ehrenberg, 1854

LOXOSTOMA DALLI (Cushman)
Plate 42, figure 22

Bifarina dalli CUSHMAN, *1926*, Cushman Lab. Foram. Research, Contr., vol. 2, p. 31, pl. 4, figs. 5 *a*, *b*.

Loxostomum dalli (Cushman), CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 38, pl. 15, fig. 3.

Occurrence.—Upper Eocene, rather rare in the Tranquilla shale, Panama.

Genus PLECTOFRONDICULARIA Liebus, 1902

PLECTOFRONDICULARIA COOKEI Cushman
Plate 42, figure 14

Plectofrondicularia cookei CUSHMAN, *1933*, Cushman Lab. Foram. Research, Contr., vol. 9, p. 11, pl. 1, fig. 26; *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 34, pl. 12, figs. 11, 12.

This spatulate, narrow *Plectofrondicularia* occurs in the Tranquilla shale and passes upward into the Alazan clays in limited numbers.

Occurrence.—Upper Eocene; Alazan, rare.

PLECTOFRONDICULARIA VAUGHANI Cushman
Plate 42, figure 15

Plectofrondicularia vaughani CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 112, pl. 23, fig. 3; *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 92, pl. 13, figs. 21, 22.—CUSHMAN and JARVIS, *1930*, Jour. Paleontology, vol. 4, p. 361, pl. 33, fig. 4.—NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 127, pl. 14, fig. 25.

Occurrence.—This species has been found from upper Eocene to Miocene in Mexico, Trinidad, Venezuela, Ecuador, and Panama. In Panama it is very abundant in the upper Eocene and Oligocene formations from Costa Rica to Darien.

Genus NODOGENERINA Cushman, 1927

NODOGENERINA COOPERENSIS Cushman
Plate 42, figure 16

Nodogenerina cooperensis CUSHMAN, *1933*, Cushman Lab. Foram. Research, Contr., vol. 9, p. 11, pl. 1, fig. 27; *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 34, pl. 12, fig. 13.

Occurrence.—Upper Eocene; common in the Tranquilla shale of Panama.

Genus BULIMINA d'Orbigny, 1826

BULIMINA JACKSONENSIS Cushman
Plate 42, figure 17

Bulimina jacksonensis CUSHMAN, *1925*, Cushman Lab. Foram. Research, Contr., vol. 1, p. 6, pl. 1, figs. 6, 7.—CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 168, pl. 7, fig. 8.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 35, pl. 13, figs. 7, 9.

Occurrence.—Abundant, upper Eocene of Panama; occurs also in the upper Eocene and Oligocene Alazan of Mexico.

BULIMINA PYRULA d'Orbigny
Plate 42, figure 18

Bulimina pyrula D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 184, pl. 11, figs. 9, 10.—CUSHMAN, *1911*, U. S. Nat. Mus., Bull. 71, p. 78, figs. 126, 127.—HOWE and WALLACE, *1932*, Louisiana Dept. Cons., Geol. Bull. 2, p. 60, pl. 11, fig. 6.

The specimens of this species from the Tranquilla shale are somewhat longer than the length of previously described specimens, and also somewhat thicker than the specimens figured by d'Orbigny. The position of the sutures and the structure of the test place these specimens within the limits of d'Orbigny's species.

Occurrence.—Tertiary.

BULIMINA INFLATA Seguenza
Plate 42, figure 19

Bulimina inflata SEGUENZA, *1862*, Accad. gioenia sci. nat., Atti., ser. 2, vol. 13, p. 109, pl. 1, fig. 10.—COLE, *1927*, Bull. Am. Paleontology, vol. 14, no. 51, p. 25, pl. 3, fig. 12.—GALLOWAY and MOREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 37, pl. 5, fig. 13.

Occurrence.—Tertiary; fairly abundant in the Tranquilla shale of Panama.

Family UVIGERINIDAE Galloway and Wissler, 1927

Genus UVIGERINA d'Orbigny, 1826

UVIGERINA SPINULOSA Coryell and Embich, n. sp.
Plate 42, figure 23

Test free, bulbous, greatest diameter near the center; consisting of about four whorls, three chambers to a whorl in the early or initial part; chambers inflated and overhanging just above the suture lines; surface extremely hispid, short stout spines covering entirely each chamber. Aperture round, simple, at the end of a short thick neck. Length 0.45 mm.

Remarks.—This species resembles *Uvigerina hispida* Schwager, found in the Pliarina. It is not of this species, however, as both the shape of the test and the neck are very different.

Occurrence.—Rather rare in the Tranquilla shale, Panama. Columbia Univ. Coll., M57.

UVIGERINA BOQUERONENSIS Coryell and Embich, n. sp.
Plate 42, figure 24

Test free, conical, greatest diameter about the middle; round or generally oval in outline of cross-section; early chambers marked with longitudinal costae for about the first three whorls; costae are confluent from one chamber to another; in the later whorls the ornamentation consists of spines; the last spinose whorl is of less diameter than the whorl preceding, more loosely arranged, and thus the outline is made more lobulate; aperture at the end of a short cylindrical neck with a phialine lip. Length 0.45 mm.

Remarks.—This species differs from *Uvigerina gardnerae* Cushman in general shape as well as in markings.

Occurrence.—Very abundant in all outcrops of Tranquilla shale, Panama. Columbia Univ. Coll., M58.

UVIGERINA ALATA Cushman and Applin
Plate 42, figure 25

Uvigerina alata CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 176, pl. 8, figs. 11–13.—ELLISOR, *1933*, Am. Assoc. Petroleum Geologists, Bull., vol. 17, no. 11, pl. 3, figs. 11, 12.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 39, pl. 15, figs. 8–10.

Occurrence.—Upper Eocene; rather rare in Tranquilla shale.

Genus SIPHONODOSARIA
Silvestri, 1924

SIPHONODOSARIA PUNTENSIS Coryell and Embich, n. sp.
Plate 42, figure 27

Test free, nodosariform, consisting regularly of two chambers only, arranged in rectilinear series; proloculum or early chamber usually larger than later chambers; wall calcareous, perforate; aperture simple, terminal, at end of extended neck. Length 0.67 mm.

This species is so common in the Tranquilla shale that one can state with confidence that there are but two chambers in an adult test.

Occurrence.—Common, Tranquilla shale, Panama. Columbia Univ. Coll., M59.

Genus ANGULOGERINA
Cushman, 1927

ANGULOGERINA SANJUANENSIS Coryell and Embich, n. sp.
Plate 42, figure 26

Test triangular; the early chambers biserial, three chambers to a whorl for the first half of the test; in the last half of the test the chambers are arranged in a uniserial order; wall thick, hyaline, coarsely perforate, surface pitted; aperture terminal, round, at the end of a short neck. Length 0.4 mm.

Remarks.—This species differs from *Angulogerina cooperensis* Cushman in the more slender portion of the uniserial part of the test.

Occurrence.—Rather common in the Tranquilla shale, Panama. Columbia Univ. Coll., M60.

Family CYCLOCLYPEIDAE
Galloway, 1933

Genus ASTEROCYCLINA
Gümbel, 1870

ASTEROCYCLINA GAMBOAENSIS Coryell and Embich, n. sp.
Plate 43, figure 16

Test biconvex, stellate, or equilateral, with four prominent rays formed by the central annular chambers swinging outward; chamberlets larger in the rays than in the central area; several layers of chambers superimposed upon one another make the central portion of the test biconvex; central zone with pillars which give the surface a pustulose effect. Diameter 0.35 mm.

Occurrence.—Common and characteristic of the upper Eocene Tranquilla shale, Panama. Columbia Univ. Coll., M61.

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H. N. CORYELL, COLUMBIA UNIVERSITY, NEW YORK CITY. JOHN R. EMBICH, FORT RILEY, KANSAS. MANUSCRIPT RECEIVED BY THE EDITOR, AUGUST 28, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 4, PP. 306–334, TEXT FIGS. 1–3,
JUNE, 1937

STRATIGRAPHIC SIGNIFICANCE OF SOME LATE PALEOZOIC FENESTRATE BRYOZOANS

MAXIM K. ELIAS

ABSTRACT

Comparative study of described fenestrate bryozoans from Carboniferous and Permian rocks of North America, Timor and elsewhere permits the conclusion that at least some of these bryozoans can be used for correlation of major subdivisions (series and groups). In the particular case of the *Walchia*-bearing beds near Garnett, Kansas, these bryozoans furnish sufficient evidence for an independent indication of the late Middle Pennsylvanian (latest Westphalian) rather than Permian (Autuno-Permian) age of the beds in which they were found. The forms which prove to be most useful for the age determination of these beds belong to the *Fenestrellina mimica* and *Polypora elliptica* groups. These fenestrellinids show distinct evolutionary change which may be generally designated as homogeneous stretching of the zoarium in both longitudinal and transverse directions. This stretching manifests itself in evolutionary increase of distance between branches, dissepiments, zooecia and spines.

In connection with the discovery of the Permian-like *Walchia* flora near Garnett, Kansas (see Elias, 1933, and Moore, Elias and Newell, 1935) in strata which unquestionably belong to the Stanton limestone formation near the top of the Missouri series, or about in the middle of the Pennsylvanian section of Kansas, I undertook work on the problem of whether the age of the *Walchia*-bearing beds could reasonably be determined from study of the marine invertebrates which were found in the same shale with the *Walchia* flora and in the thin limestone which directly overlies it. In other words, does the marine fauna of these beds contain any species that are characteristically Pennsylvanian, or characteristically Permian (precisely Autuno-Permian),[1] as the case might be, and thus provide independent check as to the age of the peculiar prolific and beautifully-preserved flora?

In view of the fact that the first collections of marine invertebrates from the locality contained only brachiopods, pelecypods and bryozoans and because it appeared that the first two kinds of collected fossils belong to long-ranging forms which are common to both local Pennsylvanian and "Permian" (Autuno-Permian) strata, I directed my attention to the Bryozoa of the collections, which were well preserved and comprised several distinct species. Inasmuch as study of the precise stratigraphic range of the numerous Pennsylvanian and Permian Bryozoa has not been sufficiently advanced, my attempt to evaluate the

[1] Autuno-Permian signifies the stratigraphic interval from the base of the Autunian (Rotliegend) to the base of the Triassic. In view of the use of the term Permian in different senses by different authors, hyphenated terms like Autuno-Permian are suggested as temporary expedients to define the stratigraphic application that is intended (see Elias, in Moore, Elias and Newell, p. 17).

stratigraphic significance of the Bryozoa from the *Walchia*-bearing beds at Garnett involved the bringing together of data in the literature on the fenestrellinids (from Fenestrellinidae Bassler, replacing Fenestellidae King, see p. 309) in North America and elsewhere in the world, and I studied also directly fenestrate Bryozoa in the extensive collections of R. C. Moore at the University of Kansas, which includes types of species described by him. I am indebted to Doctor Moore for the privilege of using his material on fenestrate Bryozoa, and to Dr. G. E. Condra for consultation in regard to the stratigraphic range of some forms.

METHOD OF STUDY

Although the use of Late Paleozoic Bryozoa for stratigraphic purposes is less advanced and accordingly less favored by paleontologists than, for instance, use of fusulinids, modern methods of morphologic study and description of these delicate, beautiful molluscoids are by no means inferior to those applied to study of Paleozoic Foraminifera. These methods have been developed chiefly by the American paleontologists, Ulrich, Rogers, Bassler, Condra, Moore, and others. Recently considerable work of high quality has been done on Russian Late Paleozoic Bryozoa by Nikiforova and Nehoroshew. Perhaps the chief distinction and greatest scientific advantage of present technique lies in its tendency to measure carefully as many features of the colonies of Bryozoa as possible; thus the description of the species became quantitative instead of qualitative merely, as tends to be the case in descriptions of brachiopods, pelecypods, and most other Late Paleozoic marine invertebrates. It is possible to tabulate features of described bryozoans in charts which show at once just how the various species differ. Such charts, which also assist in recognizing possible synonymy of species have been used by Condra (1903, pp. 110–119) and Nikiforova (1926, pp. 176, 177; 1927, pp. 246, 247; 1933; pp. 60, 61). Some of the charts accompanying this paper are somewhat different from previously prepared tables in that they not only show similarities and differences between various forms (in each case including only closely related forms) but the compared species are arranged according to their known stratigraphic succession. By this method it becomes possible to demonstrate some regular changes which seem to be of evolutionary nature. Such evolutionary changes can be recognized clearly, for instance, in the *Fenestrellina mimica* and *Polypora elliptica* groups, and through this it becomes possible to conclude that the forms of these groups from the *Walchia* beds at Garnett did not reach in their evolutionary development the stages which are typical for the Big Blue and still higher rocks of the Autuno-Permian.

PROCEDURE IN MEASUREMENTS

The measurements and calculations in the following descriptions have been made on as many specimens as available in the collections and represent average values. Owing to abnormal conditions at places of forking of branches, data pertaining to these places were excluded from consideration. The observed variations are given in the form of minima and maxima of observed values; for instance, the distance between the nodes for *Fenestrellina mimica* mut. *raymondi* is 0.19 mm. in average, with limits of variation from 0.18 to 0.20 mm. Although exceptionally, as at branching, the distances between nodes become somewhat irregular, the indicated limits of variability are believed to be correct for average measurements when these are taken for at least three or more fenestrules in succession. Although the modern students of fenestrate Bryozoa agree in general methods of study, they employ, as Moore has pointed out to me, somewhat differ-

ent methods in measurements and counts for branches, dissepiments, nodes and other features. This lack of uniformity of method results in a certain lowering of exactness in the observation and recording of measurable elements that may be stratigraphically important. This applies especially to study of a single evolutionary series, the separate members (mutations) of which have been described by different authors. In spite of this the existence of these important cumulative changes can be demonstrated, as shown in this paper, even though the published data are admittedly imperfect, both difference in methods of measurements and possible human errors detracting from exactness of figures that are used in comparative charts.

It must be realized that one may count one element (branch, fenestrule, node or others) more or less per given space (usually 5 or 10 mm.) depending on whether both the initial and the last element, or only one of them, is counted. It is considered, however, that the only correct way is to measure from center to center of an element, or from the side of one element to the corresponding side of another, as from the margin of one branch to the corresponding margin of another branch, and then count the number of intervals, thus defined, per given space. This method, described in a somewhat different way, was suggested by Moore (1929, footnote 1 to p. 15) and has been employed by me. It seems obvious that the future successful use of fenestrate Bryozoa for exact stratigraphic correlations, like that here attempted, will depend to a considerable extent upon uniformity of the methods of measurements and on personal accuracy in taking them. It is believed, furthermore, that employment of standard methods of biometry in obtaining average values for measured elements may result in still greater precision of numerical characteristics of the species and mutations which will allow use of them for still more exact correlations.

DESCRIPTION OF SPECIES

Bryozoa were collected by me from both the *Walchia*-bearing Rock Lake shale and the overlying thin South Bend limestone, the uppermost member of the Stanton limestone formation of the Missouri group, Pennsylvanian, of Kansas. These members have been designated, respectively, as Victory Junction shale and Little Kaw limestone in earlier descriptions of the Garnett section, but there no longer appears to be question as to their equivalence to previously named units in Nebraska. The locality is in the SW.¼ SE.¼ sec. 32, T. 19 S., R. 19 E., northwest of Garnett, Anderson County, Kansas. Following is a complete list of identified species in the collections, those occurring in the Rock Lake shale being designated by RL, and those in the South Bend limestone by SB.

Bryozoans of the Rock Lake shale and South Bend limestone members of the Stanton formation near Garnett, Kansas

Fenestrellina mimica (Ulrich) mut. *rogersi* Elias, n. mut. (RL)
Fenestrellina limbata (Foerste) (SB)
Fenestrellina garnettensis Elias, n. sp. (SB)
Fenestrellina geminanoda (Moore) (RL)
Fenestrellina pectinis (Moore) (RL)
Polypora moorei Elias, n. sp. (SB)
Polypora elliptica Rogers, *s. s.* (RL, SB)
Polypora nodocarinata Ulrich (SB)
Rhombopora lepidodendroides Meek (RL, SB)

In reviewing some previously described bryozoans from elsewhere the following new names are here introduced:

(1) *Fenestrellina mimica* (Ulrich) mut. *raymondi* Elias, n. mut. (= *Fenestella mimica* var. *texana* Moore, 1929). (2) *Fenestrellina mimica* (Ulrich) mut. *wellsi* Elias, n. mut. (= *Fenestella mimica* Ulrich, Dana Wells, Notes on the paleontology of the Garrison formation of Kansas, Master's thesis, University of Kansas, 1929). (3) *Fenestrellina girtyi* Elias, n. sp. (= *Fenestella spinulosa?* Girty, 1908). (4) *Polypora condrai* Elias, n. sp. (= *P. elliptica* Condra, part, 1903).

Following is a list of the bryozoans discussed in this paper:

Fenestrate Bryozoans discussed in this Paper

Fenestrellina binodata (Condra)
Fenestrellina bispinulata (Moore)
Fenestrellina conradi (Condra) var. *compactilis* (Condra)
Fenestrellina geminanoda (Moore)
Fenestrellina girtyi Elias
Fenestrellina kukaensis (Bassler)
Fenestrellina limbata (Foerste)
Fenestrellina mimica (Ulrich)
Fenestrellina mimica (Ulrich) mut. *latirama* (Sayre)
Fenestrellina mimica (Ulrich) mut. *raymondi* Elias
Fenestrellina mimica (Ulrich) mut. *wellsi* Elias
Fenestrellina parviuscula (Bassler)
Fenestrellina spinulosa (Condra)
Fenestrellina tenax (Ulrich)
Fenestrellina sp. cf. *tenax* (Nikiforova)
Polypora elliptica Rogers
Polypora koninckiana Waagen and Pichl
Polypora moorei Elias
Polypora nodocarinata Ulrich
Polypora spinulifera Ulrich
Polypora spinulifera Ulrich, var.
Polypora timorensis Bassler
Polypora timorensis Bassler var. *darashamensis* Nikiforova
Polypora tripliseriata Bassler

Family FENESTRELLINIDAE Bassler

Genus FENESTRELLINA d'Orbigny, 1849

The generic name *Fenestella* Lonsdale and, consequently, the family name Fenestellidae King, have been suppressed by Bassler (1935, pp. 17, 110, 111) because the name *Fenestella* is preoccupied for a pelecypod (*Fenestella* Bolten, 1798).

I. GROUP OF *FENESTRELLINA MIMICA* (ULRICH)

Fenestrellina mimica and its varieties or mutations have been described in the following papers:

Fenestella mimica ULRICH, E. O., *1890*, p. 552.—CONDRA, G. E., *1903*, p. 50.—BEEDE, J., and ROGERS, A. F., *1908*, chart opp. p. 328, chart on p. 376.
Fenestella mimica var. *texana* MOORE, R. C., *1929*, p. 17.
Fenestella mimica var. *latirama* SAYRE, A. N., *1930*, p. 88.

If we were obliged to base our judgment on this list of published descriptions and identifications alone, we would be compelled to conclude that all published information indicates that *Fenestrellina mimica* and its varieties have been previously found exclusively in undoubted Pennsylvanian rocks (excepting those by Condra from Bennett and Roca, Neb., which are now classed as belonging in the lower part of the Big Blue series, lower Autuno-Permian) and have not been described as yet from higher beds. Probably most paleontologists would be content to say that the presence of this form in the beds with the *Walchia* flora can be considered as indicative of its Pennsylvanian age. Such commonly practiced evaluation of the stratigraphic significance of a fossil is, however, in constant danger of being destroyed by discovery of it in beds which formerly were supposed to be beyond its stratigraphic range. Indeed, this proves to be the case with *F. mimica*, for search through the extensive collections of bryozoans at the University of Kansas has resulted in finding this form from beds as high as the "Garrison shale" (between Cottonwood and Wreford limestones) of the Big Blue series of Kansas, or in the beds within the zone of *Callipteris conferta*. Other bryozoans collected in the *Walchia*-bearing bed and in the limestone above it, except a few new forms, have also been described from both upper Pennsylvanian and Autuno-Permian beds of Kansas and Texas.

If quantitative methods of study of the fenestrate bryozoans were not developed, one would have to admit that not a single bryozoan among those collected in the *Walchia*-bearing beds at Garnett belongs exclusively to Pennsylvanian time, and therefore the bryozoans do not present any evidence in favor of either Pennsylvanian or Permian age of the beds. Exact quantitative studies, however, permit us to observe that the so-called *F. mimica* has not remained the same, but was constantly changing in certain ways. By plotting measurements

in the order of known stratigraphic sequence of the forms studied, we can see clearly that while some features, such as width of branches and number of zooecia to the fenestrule, remained constant or nearly so, other features were gradually changing. Some of these changes have been noticed by authors who described the slightly modified forms as varieties. By arrangement of these "varieties" in stratigraphic succession and by observation of the cumulative character of the changes with advance of geologic age, we reach the conclusion that these changes are not merely varietal differences but represent evolutionary changes. Thus our varieties are mutations (in the sense of Waagen, not de Vries). If this conclusion is admitted, we can see at once that the form from the Garnett locality, which is here designated as *F. mimica* mut. *rogersi* Elias, n. mut., is more advanced than *F. mimica* (Ulrich) and *F. mimica* mut. *latirama* (Sayre), and that it is less advanced than *F. mimica* mut. *raymondi* Elias and other mutations from the Big Blue and higher rocks. Such comparison indicates that the *Walchia*-bearing beds at Garnett are upper Pennsylvanian rather than Autuno-Permian. This conclusion does not seem to be in danger of being overthrown by a possible accidental discovery of the same form in the Autuno-Permian beds, because the closely related forms already discovered in these beds show a further evolutionary development of the species as described below.

It is important to remark here that the greatest difficulty in the task of construction of evolutionary series lies in the fact of existence of numerous variations and mutations that branch off from a given species in the course of its evolution. In these branches the evolutionary changes that are of the same nature as observed in the main evolutionary line are developed at a different acceleration. Thus, certain advanced evolutionary stages in development of an observed feature are, as a rule, reached in different evolutionary series at different geologic age. This phenomenon was clearly recognized, for instance, by Bisat (1924, p. 68) in his studies of the evolution of British Carboniferous goniatites. Bisat points out that changes in the character of coiling and shape of conch, increased complication of suture, and outline of aperture are developed independently, so that each species may display greater advance in one of these features and lesser advance in another. Various combinations of uneven acceleration of evolutionary development in conch, suture and aperture are observed. Facts of essentially the same nature were independently noticed by J. P. Smith in American Late Paleozoic ammonoids. For instance, picturesquely characterizing the case of retarded evolutionary development of one group of ammonoids (*Schistoceras*) as compared with greater advance of a coexistent and closely related group (*Marathonites*), he says that the former is like a "country-cousin" of the latter, "simple, slow, backward,—but coming" (Smith, 1929, p. 77).

Only when the existence of branching-off varieties and mutations, which have their own course of evolution, is recognized, the difference in acceleration of some similar evolutionary changes in different, though related and parallel lines of ascent, becomes obvious and can be analyzed. If, on the contrary, the branching-off varieties and mutations are lumped together, the picture of evolution loses clearness, and stratigraphic evaluation of evolutionary changes becomes greatly confused. This is due to the fact that if we include under one species the forms which appear to be equally advanced, but which actually belong to independent, parallel lines of ascent we not infrequently find that these really distinct forms occur at stratigraphically very different horizons. On the other hand, we often observe related forms that differ considerably in evolutionary advancement occurring side by side in the same strata.

It is a law of nature that no two exactly similar species can ever be devel-

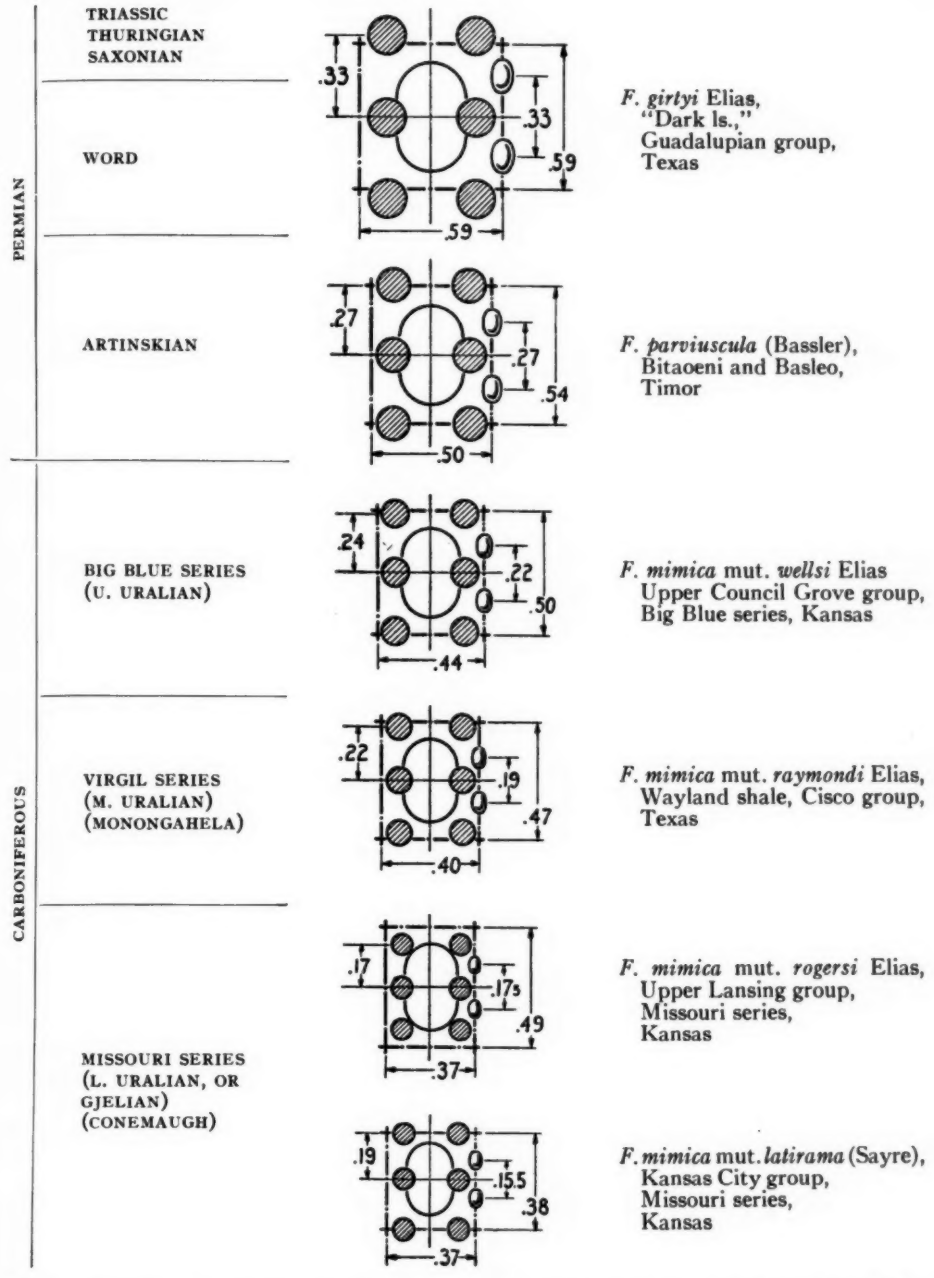


FIG. 1.—Evolution of *Fenestrellina mimica* in upper Pennsylvanian and Lower Permian epochs.

oped. Although, due, for instance, to adaptation to the same environments, species in different lines of ascent are occasionally found to display great similarity to each other (so-called convergent forms), closer study invariably reveals some fundamental constant differences in their construction which indicate their different nature. This is how existence of this phenomenon has been discovered.

In building of the evolutionary series of fenestrate bryozoans which are described in this paper, all forms known to me from the literature and in the University of Kansas collections that resemble in some way the species that were the primary subject of this research, have been studied and their possible relations analyzed. It was found that many varieties and mutations exist and that all of them can be differentiated by one or more clearly recognizable and constant features from the (selected) main evolutionary series. Description and discussion of all these forms is incorporated in the paper. Through differentiation and elimination of these forms from the main lines of ascent, the evolutionary series of *F. mimica* and *Polypora elliptica* are left to contain only those forms which do not differ in any essential way from the types of these species except that they suffered general, but quite proportional, change in size, as if the typical zoarium of these two species were uniformly magnified with the advance of geologic age, as observed.

With the mutations of *F. mimica* indicated on Table 1 are included forms here named *F. girtyi* (previously described as *F. spinulosa*(?) and *F. parviuscula*) because these seem to have been derived from the latest mutation of *F. mimica* through further evolutionary change in the same general direction. These changes consist essentially in stretching of the zoarium in both directions within its plane, as a result of which the distances between branches, dissepiments, zooecia and nodes gradually increase with advancing geologic time. These evolutionary changes are illustrated in Fig. 1. An important evolutionary feature here shown is the proportionally more rapid increase of distance between zooecia as compared with the increase of distance between dissepiments (the dissepiments themselves do not increase in width) and between nodes.

FENESTRELLINA MIMICA (Ulrich) *s.s.*

Fenestella mimica ULRICH, E. O., *1890*, Illinois Geol. Survey, vol. 8, p. 552, pl. 52, figs. 7, 7*a*. Allegheny group, Pennsylvanian, Seville, Illinois.

The principal characters measured by Ulrich, with addition of measurements by me from the published illustrations, are given on Table 1. These characters, as expressed in figures, define *F. mimica* in a restricted sense, and permit one to distinguish it from later mutations and from its probable progenitor *F. tenax* Ulrich.

FENESTRELLINA MIMICA (Ulrich) mut. LATIRAMA (Sayre)

Fenestella mimica var. *latirama* SAYRE, A. N., *1930*, Kansas Univ., Sci. Bull., vol. 9, p. 88, pl. 2, figs. 1, 1*a*. Drum limestone, Missouri series, Pennsylvanian; Independence, Kansas.

The principal characters measured by Sayre are given in Table 1. The form is considered a mutation of *F. mimica* Ulrich because it shows distinct advancement in comparison with the latter along the detected evolutionary trend for the *F. mimica* group, as discussed above. Its advanced development conforms to its higher stratigraphic occurrence. The Missouri series, where mut. *latirama* belongs, corresponds approximately to the Conemaugh, while the Seville limestone of Illinois, where *F. mimica, s.s.*, has been collected, belongs near the base of the Allegheny.

FENESTRELLINA MIMICA (Ulrich) mut. ROGERSI Elias, n. mut.
Figure 3*f–h*

In addition to characters given in Table 1, it may be noted that the zooecia

project into the fenestrules, the dissepiments are much depressed on the obverse, but nearly as high as the branches on the reverse, and the surface of branches and dissepiments on the reverse is finely granulate. The obverse is smooth. The carina is fairly prominent with one row of moderately high, stout nodes. All these features are equally characteristic of typical *F. mimica* and the several mutations of this species.

The mutation is named in honor of Dr. A. F. Rogers, formerly of the University of Kansas, now of Stanford University.

Occurrence and type.—Rock Lake shale member of the Stanton formation, near Garnett, Kans. Holotype, Kansas Univ., 221.

FENESTRELLINA MIMICA (Ulrich) mut. RAYMONDI Elias, new name

Fenestella mimica var. *texana* MOORE, R. C., *1929*, Jour. Paleontology, vol. 3, p. 17, pl. 2, figs. 18–22. Wayland shale, upper Graham formation, Pennsylvanian, Texas.

This form is considered here a mutation and is given a new name because a different species of *Fenestrellina* was described from the Delaware Mountain formation of Texas as *Fenestella texana* by Girty (1908, p. 138). Because specific and subspecific names are coördinate from a nomenclatural standpoint, the form designated as var. *texana* must be given a new name. The new mutation is named in honor of Dr. Raymond C. Moore. The additional measurements for the mutation, which are entered on the chart, have been taken on metatypes in the collection of R. C. Moore at the University of Kansas.

Occurrence.—The mutation comes from the Wayland shale, near the top of the Graham formation, Cisco group, of north-central Texas. The stratigraphic position of the Wayland shale is certainly higher than the top of the Stanton limestone formation of Kansas, where *F. mimica* mut. *rogersi* belongs, and it probably corresponds to a horizon somewhere in the upper part of the Shawnee group of Kansas.

FENESTRELLINA MIMICA mut. WELLSI Elias, n. mut.

Figure 3*i*

This form, collected by R. C. Moore, was correctly identified as *F. mimica* by Dana Wells who studied some bryozoans in Moore's collection. This extends the previously known range of *F. mimica* into the lower part of the Big Blue series of Kansas.

Additional features to those shown on the chart are: moderate projection of zooecia into fenestrules; greatly depressed nature of dissepiments on the obverse, slight on the reverse; wide prominent carina, and the stout, moderately prominent nodes.

Occurrence.—The fossil comes from the "Garrison shale" (between the Cottonwood limestone below and the Wreford limestone above), approximately from the horizon of the Eiss limestone, Council Grove group, Big Blue series, about one mile northwest of Strong City, Chase County, Kansas (Coll. 310). Holotype, Kansas Univ., 222.1, paratypes, 222.

FENESTRELLINA MIMICA mut.

Fenestrella mimica (?) JOHNSEN, A., *1906*, Bryozoen aus dem Karnischen Fusulinenkalk, Neues Jahrb., Band 2, pp. 135–160 (pp. 149, 150, pl. 11, fig. 13).

After the manuscript was completed Dr. N. D. Newell called my attention to the paper by Johnsen on bryozoans from the Carnic Alps. Among these, *F. mimica* was identified with some doubt. Although the description of the material from this locality is not quite complete, the photograph of a fragment permits observation and measurement of additional features, so that the following data can be assembled.

Measurements of Fenestrellina mimica *mut.*

Branches, number per 10 mm.	20
Fenestrules, size in mm.	0.3×0.2–0.25
Fenestrules, number in 10 mm.	19
Zooecia, number in 5 mm.	19–23
Zooecia, number per fenestrule	2
Nodes, distance in mm.	0.24
Nodes, number per fenestrule	2

Comparison of these data with those of other forms of the *F. mimica* group indicates that the Carnic Alps form is a slightly more advanced mutation than *F. mimica* mut. *wellsi*, which belongs between the occurrences of *Paraschwagerina kansasensis* and *Pseudoschwagerina* sp. cf. *P. uddeni*. The form from Carnic Alps comes from the uppermost beds of Auering or directly below the *Schwagerina*-bearing limestones of Rottenberg. It is hardly possible to conclude at present without reservations whether *Paraschwagerina kansasensis* of Kansas is older or younger than the lowermost *Schwagerina*-bearing beds of the Carnic Alps, although Kohler believes that the latter relation is correct. On the other hand, the data on *F. mimica* mut. from the Alps must be revised and taken again on originals before its exact standing in relation to the American forms can be satisfactorily established. It is sufficient at present to point out that this European form shows close relation to *F. mimica* mut. *wellsi* and comes from approximately the same part of the Uralian or the late Upper Carboniferous.

FENESTRELLINA SPINULOSA (Condra)

Fenestella spinulosa CONDRA, G. E., *1902*, Am. Geologist, vol. 30, p. 343, pl. 21, figs. 4–6; *1903*, Nebraska Geol. Survey, vol. 2, pt. 1, p. 55, pl. 10, figs. 1–5.

Condra described "two forms of growth" for his species. One has "strong branches (about their own diameter apart), stout dissepiments, and rectangular fenestrules." The other form "is more lax in growth, having wider fenestrules, as well as thinner branches and dissepiments." On which of these two recognized forms of growth the measurements were taken is not specified. The specimens were collected from Roca and Dawson, Nebr., which indicates that they belong somewhere in the lower part of the Council Grove group (Neva limestone or older). The species seems to differ from *F. mimica*, which is also identified (but not described) by Condra (1903, p. 50) from the locality at Roca, by more elevated carina and prominent conical spines which "obscure the apertures in old growth." Possibly *F. spinulosa* represents another mutation of *F. mimica*, but it is considered that the species needs additional comparative examination so that its relation to *F. mimica* can be better understood.

FENESTRELLINA PARVIUSCULA (Bassler)

Fenestella parviuscula BASSLER, R. S., *1929*, Permian Bryozoa of Timor, p. 76, pl. 241, figs. 8–13.—MARTIN, R., *1931*, De Paleontologie en Stratigraphie van Vederlandsch Oost-Indie, Bryozoa, p. 391.

Fenestrellina parviuscula Bassler from Timor seems to belong to the *F. mimica* group, and since the Bitaoeni beds in which it was found are known to correspond to the Leonard series of Texas (see J. P. Smith, 1926), the species is placed in Table 1 above *F. mimica* of the Big Blue, which corresponds to the Wolfcamp. The main distinguishing features as given by Bassler (and those measured by me on his photographs) compare well with the corresponding data for the American forms of the group, showing distinctly a further evolutionary development in the directions detected already for the American species, viz. increase of distance between the nodes along the carina and between the zooecia in the same longitudal direction, and also increase of distance between the branches and dissepiments of the zoarium. Other features, such as presence of a moderately prominent carina, the number of nodes and zooecia per fenestrule, the shape of the zooecia and smoothness of reverse side with only "delicate longitudinal lines," remain common throughout the series, including *F. parviuscula* of Timor.

Occurrence.—Permian of Bitaoeni and Basleo, Timor.

FENESTRELLINA GIRTYI Elias, n. sp.

Fenestella spinulosa (?) GIRTY, G. H., *1908*, Guadalupian Fauna, p. 137, pl. 19, fig. 4.

This species from the "dark limestone" of the Guadalupian group in the Guada-

TABLE 1.—*Stratigraphic Distribution and Characters of Species of the Fenestrellina minima Group*

TABLE 1.—*Stratigraphic Distribution and Characters of Bryozoa of the* Fenestrellina mimica *Group*

Horizon and locality	Name of species and variety	Branches		Fenestrules		Zooecia		Nodes	
		Width in mm.	Number per 10 mm.	Size in mm.	Number in 10 mm. longitudinally	Number in 5 mm.	Number per fenestrule	Distance in mm.	Number per fenestrule
"Dark limestone," Guadalupian, Guadalupe Mts., Texas.	*F. girtyi* Elias, n. sp. (*F. spinulosa*? Girty, 1908, p. 137, pl. 19, fig. 4)	0.30[a]	17[b]	0.44×0.3[a]	17[b]	15[a]	2	0.33[a]	2
Bitaoeni and Basleo, Permian; Timor.	*F. parviuscula* (Bassler) (1929, p. 76, pl. 241, figs. 8–13)	0.20	20	0.40×0.25[a]	18[a]	18[a]	2	0.25–0.29[a]	2
Middle of "Garrison shale," Big Blue series, Strong City, Kansas.	*F. mimica* mut. *wellsi* Elias, n. mut.	0.20	23	0.37×0.24	20	20–23	2–3	0.22 (0.20–0.24)	2–3
Wayland shale, Graham formation, Cisco group north-central Texas.	*F. mimica* mut. *raymondi* Elias, n. mut. (=var. *texana* Moore, 1929, p. 17, pl. 2, figs. 18–22).	0.27–0.28[c]	25[c]	0.35×0.22[c]	21–22[c]	23	2	0.19 (0.18–0.20)	3[c]
South Bend limestone, Stanton formation, Missouri series, near Garnett, Kansas.	*F. mimica* mut. *rogersi* Elias, n. mut.	0.24	27–28	0.35×0.2	20–21	28–29	2½+	0.17–0.18	2½–4
Westerville limestone, Kansas City group, Missouri series, Kansas City, Missouri.	*F. mimica* mut. *latirama* (Sayre) (1930, p. 88, pl. 2, figs. 1, 1a).	0.28	27	0.30×0.16	26	25–27	2	0.15–0.16	2½–3[a]
Seville limestone, about base of Allegheny group, Seville, Illinois.	*F. mimica* (Ulrich) (1890, p. 552, pl. 52, figs. 7, 7a).	0.25	23–24 (27)[a]	0.35×0.2	22–24	24	2	0.12	3.5[b] or 3[a]
Lower Carboniferous, Russian Turkestan.	*F.* cf. *tenax* (Nikiforova)		26–30		26–27	25			
Warsaw formation, Mississippian, Illinois.	*F. tenax* (Ulrich)	0.20–0.30	28–30	0.30×0.16	29–30	28–29	2	Small, numerous	

[a] Measured or counted on published illustrations.
[b] Computed from author's measurements.
[c] Measured or counted on the metatype.

lupe Mountains of Texas has appropriately been compared by Girty with *F. spinulosa* (Condra). A closer comparison of the main features of the Guadalupian form, partly additionally measured by me on Girty's photographs, seems to show, however, that it differs from *F. parviuscula* about as much as the latter differs from *F. spinulosa*, the three forms belonging probably to one line of descent. If this conclusion is correct, the Timor and Texas forms are mutations of *spinulosa*.

The Texas form which is here given the name *F. girtyi* seems to be more advanced than *F. parviuscula*, which is in agreement with its somewhat higher stratigraphic position. On the ground of distribution of some important ammonoids, the "dark limestone" of the Guadalupian group seems to correspond to the upper part of the Word formation of Texas and to the upper part of the Basleo of Timor.

The species is named in honor of Dr. G. H. Girty of the U. S. Geological Survey.

Occurrence.—"Top of Capitan formation, Capitan Peak (station 2966); 'dark limestone,' Pine Spring (Station 2930), Guadalupe Mountains, Texas. Delaware Mountain formation, southern Delaware Mountains, Texas (station 2269?)."

The illustrated specimen on which the measurements by me were taken came from the "dark limestone," Guadalupe Point (station 37622) and is here designated as the holotype of *F. girtyi*.

FENESTRELLINA TENAX (Ulrich)

Fenestella tenax ULRICH, E. O., *1890*, Illinois Geol. Survey, vol. 8, p. 546, pl. 51, figs. 2–2*e*. Warsaw formation, Illinois.

This Mississippian species is added to discussion of the *Fenestrellina mimica* group because its observed features and low stratigraphic position indicate that it is possibly the ancestor of *F. mimica*. It is interesting that *F. tenax*, according to Ulrich, bears numerous small spines, not counted by that author apparently on account of their small size and crowded spacing. In *F. mimica* and the succeeding mutations these nodes become more prominent and more distinctly spaced.

FENESTRELLINA sp. cf. F. TENAX (Nikiforova)

Fenestella cf. *tenax* NIKIFOROVA, A. J., *1933*, United Geol. Prosp. Service U.S.S.R., fasc. 268, p. 15.

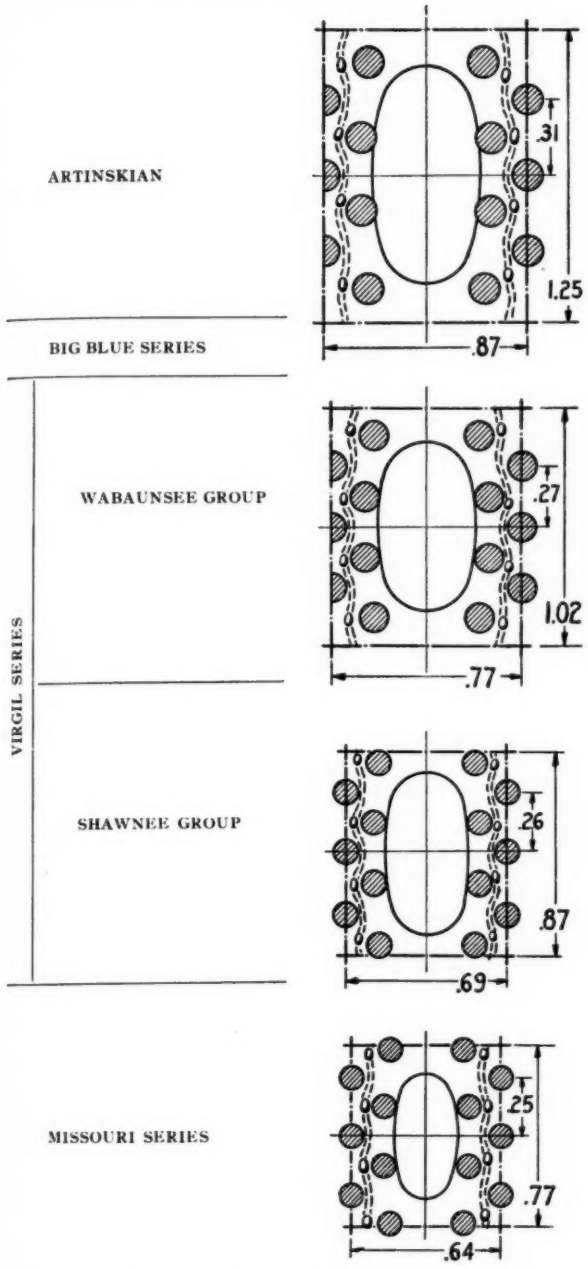
Nikiforova described from the Lower Carboniferous of Russian Turkestan a form which she compares with *F. tenax*. It seems to have features intermediate between those of *F. tenax* and *F. mimica*; but unfortunately no data are given in regard to nodes.

FENESTRELLINA VENERIS (Fischer von Waldheim)

This species from the Moscovian and Uralian of European Russia possibly belongs to the *F. mimica* group, but on account of incomplete descriptions and the poor published illustrations it cannot be compared with the above described forms in detail.

Evolution of the Fenestrellina mimica *group*

The accompanying Table 1 and Fig. 2 permit the following conclusions. The general evolutionary development may be defined as a homogeneous stretching of the zoarium in both longitudinal and transverse directions. Thus, the number of branches per 10 mm. width changes from 30 in *F. tenax* of the Mississippian to 17 in *F. girtyi* of the Middle Permian, although it must be admitted that in intermediate forms this change seems to come about somewhat irregularly. This apparent irregularity may possibly be due, however, to lack of exact uniformity in the method of counting by different authors who described these forms. The number of branches (23 to 24 per 10 mm.) in *F. mimica* from Seville, Ill., seems to be particularly low and possibly does not represent the average spacing for the species. On Ulrich's illustration one can count 27 branches per



P. tripliseriata Bassler,
Bitaoeni,
Timor

P. elliptica mut. β. Elias,
Howard limestone,
Kansas

P. elliptica Rogers,
Oread limestone,
Kansas

P. elliptica mut. α Elias,
Drum limestone,
Kansas

FIG. 2.—Evolution of *Polypora elliptica* in upper Pennsylvanian and Lower Permian epochs.

10 mm., which is close to the number of branches both in *F. mimica* from the Missouri series (Pennsylvanian) and *F. tenax* from the Warsaw beds (Mississippian). It may be pointed out that the change in number of branches from mut. *rogersi* through mut. *raymondi* and *wellsi* to *F. spinulosa* is very distinct and regular and helps to distinguish these closely related forms between themselves.

The number of fenestrules per 10 mm. of length changes also from 30 in *F. tenax* to 17 in *F. girtyi*. The number of zooecia per 5 mm. of length changes in similar fashion, but it appears that this feature depends to some extent also on the arrangement of zooecia in relation to fenestrules. Ordinarily there are two zooecia per fenestrule, but whenever this simple relation changes to nearly five zooecia per two fenestrules, as in mut. *rogersi* and in mut. *wellsi*, the number of zooecia per given length seems to become somewhat greater than one would expect it to be, judging from the stratigraphic position of a form in question.

The most regular evolutionary change seems to occur in the spacing of the nodes along the carina. The distance between these nodes changes from 0.12 mm. in *F. mimica* to 0.33 mm. in *F. girtyi*, while in the intermediate forms this distance increases very gradually with the stratigraphic ascent of these forms.

II. CHARACTER AND RANGE OF *FENESTRELLINA LIMBATA*

The forms which come from various horizons of the Pennsylvanian and the lower Autuno-Permian and which are identified with *Fenestrellina limbata* Foerste do not show distinct cumulative trends comparable to those displayed by the *F. mimica* group, and therefore I offer no suggestions for differentiation of stratigraphic mutations among these forms.

FENESTRELLINA LIMBATA (Foerste)

Figure 3*j*, *k*

Fenestella limbata FOERSTE, A. F., *1887*, Denison Univ. Sci. Lab., Bull., vol. 2, pt. 1, p. 83, pl. 7, figs. 10*a–d*.—CONDRA, G. E., *1904*, Nebraska Geol. Survey, vol. 2, p. 51, pl. 8, figs. 2, 3.—NIKIFOROVA, A. J., *1926*, Bull. Com. Géol., Leningrad, vol. 45, pp. 175–177, pl. 4, fig. 1; *1927*, Bull. Com. Géol., Leningrad, vol. 46, pp. 246, 247, pl. 12, fig. 1.

Fenestrellina limbata seems at first glance to be very much like *mimica* and its mutations, the resemblance including the general magnitude of the zoarium and its details. The main difference between the two species is the shape of the zooecia (which are round in the *F. mimica* group and pyriform in *F. limbata*) and the profile of the zoarium (flatter in *F. limbata* than in *F. mimica*). The pyriform shape of the zooecia in *F. limbata* is produced through a slight proximal extension of the otherwise circular aperture. The zooecia of *F. limbata* are also comparatively more shallow than those of *F. mimica* and its kin. Other features of *F. limbata* are shown on Table 2. In spite of some variation, none of these seems to be cumulative in vertical (stratigraphic) direction within the known range of the species. Only the spacing of nodes shows some regularity of change from more distant spacing in the form from the Lower Carboniferous of Russia to closer spacing in the original form from the upper Pottsville, after which the distance between the nodes increases again in the specimens collected from the Missouri and the Big Blue series of Kansas and Nebraska. It is interesting also to observe that the number of nodes is two or slightly less per fenestrule in the latter rocks, while in the forms from the Pottsville and earlier rocks there are three nodes per fenestrule, in so far as one can judge from the illustrations (this feature not being mentioned in the authors' descriptions).

F. limbata from the South Bend limestone at the *Walchia* locality near Garnett, Kans., is a fairly typical representative of the species (see measured features in Table 2 and figs. 3*j*, *k*).

III. GROUP OF *FENESTRELLINA SUBRUDIS*

The characteristic numerical data for various forms of this provisional group

TABLE 2.—*Stratigraphic Distribution and Characters of* Fenestrellina limbata

Horizon and locality	Source	Branches		Fenestrules		Zooecia		Nodes	
		Width in mm.	Number per 10 mm.	Size in mm.	Number in 10 mm. longitudinally	Number in 5 mm.	Number per fenestrule	Distance in mm.	Number per fenestrule
Florena shale, Big Blue series, Kansas.	Univ. of Kansas coll.	0.28	22	0.35×0.20	22–23	22–23	2	0.26–0.27	2 or less
"About base of Permian" (lower part Big Blue series), Bennett, Nebraska.	Condra (1904, p. 51, pl. 8, figs. 2, 3).	0.23–0.25	24–28	0.34×0.18 (to 0.3×0.15)		23–25	2 (rarely 3)	0.21	2
South Bend limestone, Stanton limestone, Missouri series, near Garnett, Kansas.	Univ. of Kansas coll.		23+		26	27	2	0.22	2 or less
Lower Mercer limestone, upper Pottsville, Flint Hill, Ohio.	Foerste (1887, p. 83, pl. 7, figs. 10a–d).		20–26		19–26	23[a]	2 (rarely 3)	0.16	3[a]
Division C_1^4, Lower Carboniferous (Visean, Nikiforova, 1933, p. 12), Donetz Basin, Russia.	Nikiforova (1927, pp. 246, 247, pl. 12, fig. 1).	0.2 –0.25	24–26	0.25–0.30 ×0.175–0.2	20–21	24–26		0.20	3[a]
Lower Carboniferous, Russian Turkestan.	Nikiforova (1926, pp. 175–177, pl. 4, fig. 1).	0.19–0.25 (rarely 0.3)	20–24	0.25–0.4 ×0.18–0.2	22–24	20–24		0.20–0.30 (variable)	

[a] Measured or counted on illustrations.

are tabulated together on Table 3 for convenience of comparison with the new species *F. garnettensis* and to help further research on these and related forms. The following species are considered to belong to this group: *Fenestrellina missouriensis* (Rogers) (1900, p. 6, pl. 2, fig. 2), from Kansas City, Missouri; *Fenestrellina subrudis* (Condra) (1902, p. 349, pl. 21, figs. 10, 11; 1903, p. 62, pl. 9, figs. 9–11), from the Shawnee group of Nebraska; *Fenestrellina pulchradorsalis* (Bassler) (1929, p. 74, pl. 240 [16], figs. 10–13; pl. 242 [18], figs. 1–4), from the Permian of Somohole and Bitaoeni, Timor, East Indies, (Martin, 1931, p. 392); "*Fenestella* cf. *pulchradorsalis* Fritz" from the Permian limestone of Vancouver Island, British Columbia (Fritz, 1932, p. 99) which is here compared to *F. subrudis* Condra; and *Fenestrellina garnettensis*, n. sp.

It seems clear that while forms included under *F. missouriensis* are closely related and show some evolutionary changes, *F. garnettensis* and *F. rudis* Ulrich are related but genetically different lines which probably have had their own independent evolutionary development parallel to *F. missouriensis*. *F. rudis* (Ulrich) (1890, p. 537, pl. 49, figs. 3–3*d*) from the Mississippian of Iowa and Illinois, is at once distinguished from the rest of the species in question by its large elongated nodes.

No forms of closer affinity of *F. garnettensis* than *F. missouriensis* have been described, and therefore the stratigraphic range of this new species is yet to be established.

FENESTRELLINA GARNETTENSIS Elias, n. sp.
Figure 3*a–c*

Zoarium very delicate, slowly expanding, with rarely forking straight branches. When forking, the branch rises out of the plane of the zoarium either toward obverse (in the holotype) or reverse about one-half its thickness and subsides to a position flush with the rest of the branches within two or three fenestrules above the forking. It appears as if through this device the approximate normal spacing between the branches (as soon as possible after their

EXPLANATION OF FIGURE 3

a–c—*Fenestrellina garnettensis* Elias, n. sp. *a*, Obverse of holotype, ×10. *b*, Detail with three imperfectly-preserved zooecia, ×25. *c*, Cross-section of a branch, ×50. South Bend limestone member of Stanton formation at *Walchia* locality northwest of Garnett, Kans. Holotype, Kans. Univ., no. 224.1. (p. 320)

d, e—*Fenestrellina geminanoda* (Moore). *d*, Detail showing two rows of spines, ×45. *e*, Detail showing three spurs ornamenting a single zooecium, ×25. Rock Lake shale member of Stanton formation at *Walchia* locality, northwest of Garnett, Kans. Holotype, Kans. Univ., no. 225. (p. 323)

f–h—*Fenestrellina mimica* mut. *rogersi* Elias, n. mut. *f*, Obverse of holotype, ×11. *g*, Side view of branch, ×12. *h*, Cross-section of branch, ×12. Rock Lake shale member of Stanton formation at *Walchia* locality, northwest of Garnett, Kans. Holotype, Kans. Univ., no. 221. (p. 312)

i—*Fenestrellina mimica* mut. *wellsi* Elias, n. mut. Obverse of holotype, ×10. Eiss limestone (?), Council Grove group, Strong City, Kans. Holotype, Kans. Univ., no. 222.1. (p. 313)

j, k—*Fenestrellina limbata* (Foerste). *j*, Obverse of zoarium, with juvenile specimen of *Triticites* cf. *moorei* attached at the top, ×10. *k*, Oblique view showing low central nodes and pyriform shape of zooecia, ×30. South Bend limestone member of Stanton formation at *Walchia* locality northwest of Garnett, Kans. Plesiotype, Kans. Univ., no. 223. (p. 325)

l—*Polypora moorei* Elias, n. sp. Obverse of holotype (sand grains at bottom of two fenestrules). South Bend limestone member of Stanton formation at *Walchia* locality northwest of Garnett, Kans. Holotype, Kans. Univ., no. 226.1. (p. 327)

m—*Polypora elliptica* Rogers. Part of holotype (lost), after Rogers (1900, pl. 4, fig. 2), ×27. Oread limestone?, Kansas. (p. 335)

n—*Mazonia hungerfordi* Elias, n. sp., ×1. Rock Lake shale member of Stanton formation at *Walchia* locality, northwest of Garnett, Kans.

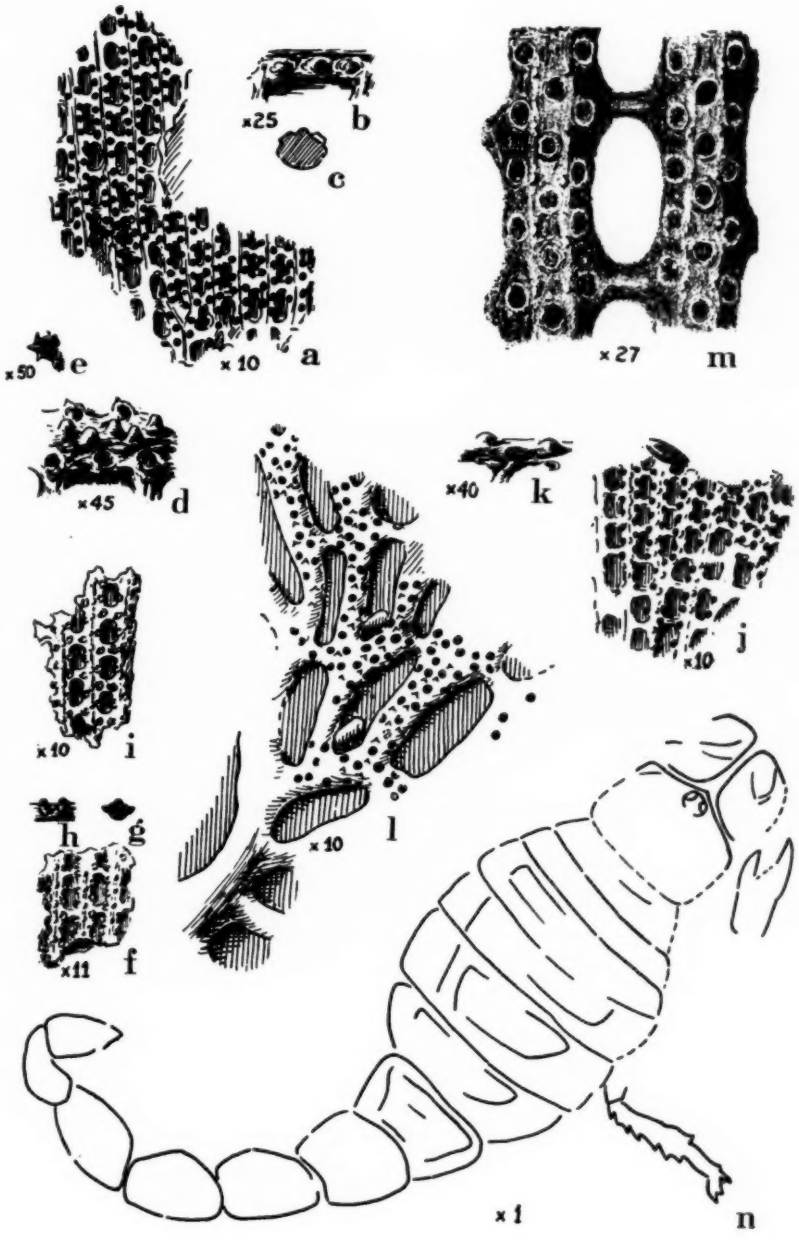


FIGURE 3

TABLE 3.—*Stratigraphic Distribution and Characters of Bryozoa of the* Fenestrellina subrudis *Group*

Horizon and locality	Source	Branches		Fenestrules		Zooecia		Width of carina in mm.	Nodes
		Width in mm.	Number per 10 mm.	Size in mm.	Number in 10 mm. longitudinally	Number in 5 mm.	Number per fenestrule		
Somohole and Bitaoeni (Permian) Timor.	*F. pulchradorsalis* (Bassler), (1929, p. 74, pl. 240, figs. 10–13, and pl. 242, figs. 1–4).	0.4	13	0.75 ×0.5[a]	10	15	3	0.055	none
"Lower Permian ls.," Vancouver Island, British Columbia.	*F. subrudis* (= *F.* cf. *pulchradorsalis* (Fritz), (1932, p. 99)		16		10	15–20[b]	3 or 4		faint
Lower Shawnee group, Virgil series, Cass County, Nebraska[c].	*F. subrudis* (Condra), (1902, p. 349, pl. 21, figs. 10, 11; 1903, p. 62, pl. 9, figs. 9–11)	0.35–0.45	16	0.55 ×0.24	12	17–18	3	0.06	none
South Bend ls., Stanton formation, Missouri series, near Garnett, Kansas.	*F. garnettensis* Elias, n. sp.	0.185	24–25	0.425 ×0.16	18–20	28–29	3	0.025	none
Kansas City group, Missouri series, Kansas City, Missouri.	*F. missouriensis* (Rogers), (1900, p. 6, pl. 2, fig. 2)	0.3	20	0.6× 0.3	13	19	3	0.075	none

[a] Measured on illustration.
[b] Computed from the published data.
[c] Beds formerly thought Shawnee in Cass County are now known to belong to Missouri series; R. C. Moore.

forking) is provided. Branches are 0.185 mm. wide, and 24 to 25 per 10 mm. Fenestrules 0.425 by 0.16 mm., 18 to 20 occurring in 10 mm. of length; they are oval in shape due to narrowing of the dissepiments at the middle. Dissepiments 0.08 to 0.09 mm. wide in the middle, depressed and marked by striae on both sides. Zooecia round, with diameter 0.09 mm., to elliptical, with long diameter up to 0.125 mm. They are located alternately on opposite sides of the straight or very slightly flexuous carina, which, though quite distinct, is low and narrow, 0.025 mm. wide. There are only slight suggestions of nodes upon the carina. Zooecia somewhat elevated upon nearly flat inclined slopes of the branches, three zooecia per fenestrule, and 28 to 29 per 5 mm. along the branches. Reverse side of branches prominently striated.

The striation of the reverse of the branches and the more delicate general appearance of the zoarium distinguish this species from *F. missouriensis* and related forms to which it bears the closest resemblance. The characteristic features of *F. missouriensis* and related forms are the slowly expanding zoarium, very distinct but low straight carina with only slight suggestion of nodes, oval shape of fenestrules and comparatively very regular number of three zooecia per fenestrule. The reverse of the zoaria in this group is granular.

Occurrence.—South Bend limestone member at the top of the Stanton limestone formation, at the *Walchia* locality, northwest of Garnett, Kans. Holotype, Kansas Univ., 224.

IV. SPECIES OF *FENESTRELLINA* WITH DOUBLE ROW OF SPINES ON CARINA

The forms of this group are tabulated together on Table 4 for convenience of comparison and to help further research on these interesting bryozoans.

FENESTRELLINA GEMINANODA (Moore)

Figure 3*d*, *e*

Fenestella geminanoda MOORE, R. C., *1930*, Denison Univ. Sci. Lab., Bull., vol. 25, p. 150, pl. 26, figs. 5, 6.

The excellently preserved specimen in the Rock Lake shale agrees in all features with the species from Texas described by Moore. His description is as follows.

> Branches straight, about 0.27 mm. wide and 0.35 mm. thick, with 12 branches in 5 mm. The dissepiments, about half the width of the branches, are slightly depressed on the obverse face but not depressed on the reverse side. Fenestrules subelliptical, margins distinctly indented by projecting zooecia, 7.5 to 8.5 fenestrules in 5 mm. Zooecial apertures subcircular, about 0.1 mm. in diameter, surrounded by a thin peristome which in many cases is incomplete on the posterior side; there are 17.5 zooecia in 5 mm. and two to three to each fenestrule. The median portion of the obverse face of the branches shows a clearly defined carina on which is a double row of low alternating nodes, about 18 in each series in 5 mm.; there is one node obliquely below each zooecial aperture. The obverse side of branches and dissepiments bear more or less distinct longitudinal granules; the reverse side is somewhat unevenly striated and slightly nodose.

Owing to excellency of preservation of the specimen from Garnett, the following additional features of the species can be added. The peristomes are ornamented with lateral sharp nodes or spurs, usually three per peristome (see fig. 1*e*). There is a distinct sinus at the posterior of the peristomes, which accounts for Moore's (1930, p. 150) comment that the "thin peristome in many cases is incomplete on the posterior side." The median nodes are more slender in this species than in *F. bispinulata* Moore (1930, p. 148) and besides their elliptical bases are oriented parallel to the branches of the zoarium, while the similarly elongated bases of the nodes in *F. bispinulata* are obliquely oriented.

In the collection of bryozoans at the University of Kansas, I found a specimen from the "Garrison shale" of Kansas, which is nearly identical with *F. geminanoda* from Texas and from near Garnett. The measured features of the "Garrison" form are entered in Table 4. It is interesting to observe that the specimen from the "Garrison shale" has about 20 zooecia per 5 mm., while the Garnett form and the type from Texas have 17.5

TABLE 4.—*Stratigraphic Distribution and Characters of Species of* Fenestrellina *with Carina bearing Double Row of Spines*

Horizon and locality	Species	Branches		Fenestrules		Zooecia		Nodes		
		Width in mm.	Number per 10 mm.	Size in mm.	Number per 10 mm. of length	Number in 5 mm.	Number per fenestrule	Number per zooecia	Number per fenestrule	Shape and size
Amarassi, Permian, Timor.	*F. kukaensis* (Bassler)	0.5	8	1.1 ×0.45	8	about 18.5 (counted on photograph)	4	1	4	round, prominent (carina absent)
"Garrison shale," Big Blue series, Kansas.	*F. conradi* var. *compactilis* (Condra)[a]	0.35 (0.35–0.4)	about 20		17–18	18	2 (never 3)	1	4	compressed, small
"Garrison shale," Big Blue series, Kansas.	*F. geminanoda* (Moore)[a]	0.27–0.28	20–24			about 20	2 freq. 3	1	4 freq. 6	slightly compressed, prominent
Wabaunsee and Shawnee groups, Virgil series, Nebraska.	*F. conradi* var. *compactilis* (Condra)	0.35 (0.3–0.4)	18–19	0.35 ×0.25	17–18	18	2 (never 3)	1	4	small
Wabaunsee and Shawnee groups, Virgil series, Nebraska.	*F. binodata* (Condra)	0.35–0.4	12–16	0.6–0.7 ×0.35	12–13	18–20	3 or 4	1	6–8 inferred from sketch	conical, coarse
Rock Lake sh., Stanton formation, Missouri series, Garnett, Kansas.	*F. geminanoda* (Moore)[a]	about 27	20–about 25		15–?	17.5–18	2 freq. 3	1	4 freq. 6	prominent compressed
Graham formation, Cisco group, Graham, Texas.	*F. geminanoda* (Moore)	0.27	24		15–17	17.5	2 freq. 3	1	4 freq. 6	prominent compressed
Ranger limestone, Canyon group, Bridgeport, Texas.	*F. bispinulata* (Moore)	0.27	20–5 (19–23)	0.4 ×0.22	18–20	18.5–19 (17.5–20)	2	1	4	conical, coarse

[a] Data by M. K. Elias from the original material in R. C. Moore's collection.

to 18 zooecia per 5 mm. This is the only difference between the earlier (late Pennsylvanian) form of *F. geminanoda* and that from the basal part of the Autuno-Permian.

Other described Late Paleozoic fenestrate bryozoans with double rows of nodes include *F. binodata* (Condra), *F. conradi compactilis* (Condra), and *F. kukaensis* (Bassler). These are entered for comparison in Table 4.

Genus POLYPORA McCoy, 1844

V. GROUP OF *POLYPORA TIMORENSIS*

To this group of *Polypora*, one of the most characteristic features of which is the rapidly expanding zoarium, undoubtedly belongs the newly described *P. moorei* Elias from the South Bend limestone. This is the first record of a species of this group in the Pennsylvanian rocks, unless *P. timorensis* var. *darashamensis* Nikiforova (1933, pp. 16, 17, 22, 38; pl. 4, figs. 4–9) described from the "Permian" (according to N. N. Yakovlew) of Araks, Djulfa, is eventually referred to the Uralian, which seems to be quite possible, and if it is agreed that Uralian corresponds to part of the Pennsylvanian.

POLYPORA MOOREI Elias, n. sp.
Figure *3l*

Zoarium fan-like, expanding very rapidly, branches bifurcating once in the space of each two fenestrules or less. Average diameter of branches is about 0.4 mm., except toward points of bifurcation where they grow considerably thicker (to 0.8 mm.). There are 11 to 12 branches per 10 mm. Dissepiments short, narrowed in the middle, and depressed both on obverse and reverse, but they are nearly as wide as the branches. Fenestrules elongate oval, usually narrowed proximad due to frequent bifurcation of branches, averaging 0.6 by 1.6 mm., five to six fenestrules occurring in 10 mm. Zooecia round and arranged somewhat irregularly in three rows and at bifurcation in four rows. There are about 6 or 7 zooecia in a row per fenestrule, and about 20 zooecia per 5 mm. Obverse surface smooth except for small round nodes, one to each zooecium. These nodes are bluntly rounded, not sharply pointed, as one might conclude from the sketch, which shows diagrammatically their position between the zooecia. The basal portion of the obverse base which does not bear zooecia, the dissepiments, and the reverse are all faintly striated, and with advanced weathering the striation appears coarser.

Remarks.—The species is most closely comparable to *P. timorensis* Bassler (1929, p. 79, pl. 253 [19], figs. 1–4) and the two seem to belong to one genetic group. The new species differs from *P. timorensis* of Basleo (Martin, 1931, p. 392), Timor, by its somewhat more rapidly expanding zoarium, and especially by its much more delicate construction, which can be seen at once by comparison of the number of branches and fenestrules per given space (see table). Although Bassler (1929, p. 79) remarks that *P. timorensis* is "without any special surface ornamentation," the enlarged photograph seems to show a few somewhat irregularly spaced faint nodes.

P. timorensis var. *darashamensis* Nikiforova (1933, pp. 16, 17, 22, 38; pl. 4, figs. 4–9) from Araks, Djulfa, resembles the new species from the South Bend limestone still closer, having the same number of branches and fenestrules, but *P. moorei* differs in having more zooecia (20 per 5 mm.) than the form from Araks in Kaukasis (15 per 5 mm.).

The somewhat similar species *P. elliptica* Rogers from the Pennsylvanian and *P. spinulifera* Ulrich from the Pennsylvanian and Mississippian are distinguished from *P. moorei* and *P. timorensis* by having shorter fenestrules and especially by the much slower expansion of the zoaria. *Polypora koninckiana* Waagen and Pichl from the middle Productus limestone of the Himalayas seems to belong to the *P. timorensis* group, although it has more rows of zooecia (5 to 7). This species is coarser than *P. tim-*

TABLE 5.—*Stratigraphic Distribution and Characters of Bryozoa of the* Polypora timorensis *Group*

Horizon and locality	Species	Branches		Fenestrules		Zooecia		
		Width in mm.	Number per 10 mm.	Size in mm.	Number in 10 mm. longitudinally	Number in 5 mm.	Number per fenestrule	Number of rows
Middle Productus ls., Himalayan Mtns., India.	*P. koninckiana* Waagen and Pichl	0.9 –1.0[a]	5–6		4	12[b]	6	5–7 (regular)
Basleo, Permian, Timor.	*P. timorensis* Bassler (1929, p. 79, pl. 243, figs. 1–4)	0.45	7– 8		4–4.5	13[a]	5–6	4
"Permian" (after N. Jakovlew) Araks, Djulfa.	*P. timorensis* var. *darashamensis* Nikiforova (1933, pp. 16–77, 22, 38, pl. 4, figs. 4–9)	0.56–0.83	12	1.28–1.61 ×0.44–0.56	5–6	15	about 5–6[a]	4[a]
South Bend ls., Stanton formation, Missouri series, near Garnett, Kansas.	*P. moorei* Elias, n. sp.	0.4	11–12	1.6×0.6	5–6	20	5–7	3 (to 4)

[a] Measured or counted on the published illustrations.
[b] Computed from other measurements.

orensis, which is in accord with its higher stratigraphic position, this conclusion being based on the occurrence of characteristic ammonoids.

Occurrence.—*P. moorei* was collected from the South Bend limestone member of the Stanton formation, Missouri series, Pennsylvanian, at the *Walchia* locality, northwest of Garnett, Kans.

The species is named after Dr. R. C. Moore of the University of Kansas. Holotype, Kansas Univ., 226.

VI. *POLYPORA ELLIPTICA* AND RELATED SPECIES

The species under discussion are somewhat similar to the above described *Polypora moorei*, but are distinguished by a slowly expanding zoarium, and they have shorter, nearly square fenestrules. These forms are quite common in the Late Paleozoic rocks of the northern Mid-Continent. Condra (1902, p. 69) observes that *P. elliptica* "is the best represented species of the genus found in Nebraska," and Rogers (1900, p. 8), who erected the species, notes that "this is one of the commonest species of bryozoans in the collections" from Kansas studied by him. Rogers also observed that the species is "quite variable in its characters," and an attempt was made by Condra (1903, pp. 69–72) to separate and name some of the varieties. The relation of the species to *P. nodocarinata* Ulrich from Illinois has been suggested by Rogers, who says that "some of the specimens are much more closely related to *P. nodocarinata* than others." Condra (1903, p. 20) pointed out the close resemblance of *P. elliptica* to *P. spinulifera* Ulrich, to which species he was inclined to refer some of his varieties prior to publication by Rogers of his species.

The stratigraphic range of the discussed forms is from the Chester series, Mississippian, of Illinois (*P. spinulifera*, *s. s.*) to the Big Blue series of Kansas and Nebraska, and to the Permian of Timor (*P. tripliseriata* Bassler). As will be pointed out below, however, the stratigraphic range of *P. elliptica* in a restricted sense is narrower.

POLYPORA ELLIPTICA Rogers (SENSU STRICTO)

Figure 3*m*

Polypora elliptica ROGERS, A. F., *1900*, Kansas Univ. Quart., vol. 9, pp. 7, 8, pl. 4, fig. 2.—Part, CONDRA, G. E., *1903*, Nebraska Geol. Survey, vol. 2, pp. 69–72, pl. 12, figs. 1–13 (not pl. 11, figs. 4–11).

Following is the description of *P. elliptica* by Rogers (1900, pp. 6, 8).

Zoarium a reticulate expansion. Branches slightly flexuous, convex, 0.4 to 0.5 mm. wide, seven to eight in 5 mm. Dissepiments short, subcarinate, about half as wide as the branches. Fenestrules elliptical (especially in worn specimens), averaging about 0.6 by 0.3 mm., with from five to six occurring in 5 mm. Zooecia in three or four alternating ranges, which number is often reduced to two for a very short distance after a bifurcation. The typical number of ranges is three when the central row forms the flat median summit of the branch. In this case the number is increased to four shortly before bifurcating. Apertures small, subcircular, about one and one-half times their diameter apart longitudinally. The rows of apertures are separated by inconspicuous undulating ridges, which are at intervals elevated to form small nodes, about as numerous as the apertures. The ridges are more prominent in worn specimens. On the reverse, the dissepiments and the branches are on the same plane. The latter are finely striated.

Position and locality: Upper Coal Measures; Kansas City, Mo., Argentine, Lawrence, and Topeka, Kan. Type in author's collection.

The only species with which this is liable to be confounded is *P. nodocarinata* Ulrich. In our species, the typical number of zooecial ranges is three rather than four. The branches are somewhat flexuous and not straight. The carinate appearance is not so marked and the nodes are not so prominent. The number of branches and fenestrules in 5 mm. is another distinction between the two species. This is one of the commonest species of bryozoans in the collection studied, and is quite variable in its characters. Some of the specimens are much more closely related to *P. nodocarinata* than others.

Although Rogers did not indicate specifically that the illustrated specimen is the type, the fact that only one specimen was illustrated and that the description fits it precisely leaves no other choice

but to accept the illustrated specimen as representing the type.

For his careful study of *P. elliptica* and its varieties, Condra secured from Rogers a set of "type specimens for comparison." He concluded that "specimens received from Mr. Rogers are thought to be identical with those represented on pl. 11, figs. 4–9." Correct as this comparison may be, it is quite clear from illustrations furnished by Condra (pl. 11, figs. 4–9) and from his description (p. 70) that his specimens have no carinas and the "few small spines" arise directly from the surface of the obverse. Contrary to this, Rogers observes that in *P. elliptica* "the rows of apertures are separated by inconspicuous undulating ridges, which are at intervals elevated to form small nodes, about as numerous as the apertures." These ridges and nodes are clearly shown on the illustrated specimen by Rogers. In view of this, I was inclined at first to consider that *P. elliptica* (*s. s.*) is a form which has ridges (inconspicuous as they may be) developed between the rows of zooecia and carrying nodes "about as numerous as the apertures," and I thought that inasmuch as the "type specimens" which were received by Condra from Rogers did not possess any ridges, they probably did not include the actual type specimen illustrated by Rogers. In his description, Rogers mentions only one "type in author's collection." After persistent search, however, I discovered both "carinate" and "noncarinate" surfaces on the same specimens of *P. elliptica* (No. 8333, coll. by J. W. Beede), from Topeka, Kans., probably from the Howard limestone, and on a specimen from the Deer Creek limestone (No. 829, coll. by R. C. Moore). Upon close examination, I conclude that what appears as a carina is a thin rodlike structure sunk under the surface of the zoarium and exposed only when the surficial layer of the zoarium is somewhat eroded or weathered. A similar structure has been probably described by Ulrich (1890, p. 597) for *Polypora corticosa* of the Chester group of Illinois, in which the rows of zooecia are "separated by a fine wavy line that is alternately stronger and weaker and occasionally sufficiently elevated to form a small node or spine." No surficial elevation above this rodlike structure has been observed and the nodes appear to arise directly from the surface, as correctly observed by Condra. The specimens sent to him by Rogers apparently were not touched by erosion. Such perfect specimens were observed by me in Kansas University Coll. 1242 from the Topeka limestone.

POLYPORA ELLIPTICA Rogers mut. α Elias (early mutation)

Polypora elliptica SAYRE, A. N., *1930*, Kansas Univ., Sci. Bull., vol. 19, pp. 89, 90, pl. 3, figs. 2–4.

I collected seven specimens of *P. elliptica* (*s. s.*) from the South Bend limestone, exposed directly above the *Walchia*-bearing beds northwest of Garnett. All these specimens have the spines set on two inconspicuous rodlike structures and arranged in groups of four around the central zooecia. The average values of measurements taken on these specimens are shown on Table 6.

The studied specimens from near Garnett (and others from the Oread limestone and higher beds of the Virgil series) show clearly that arrangement of the zooecia in three rows is a constant feature in *P. elliptica* (*s. s.*). A fourth row is added only within the last fenestrule before a bifurcation. After the bifurcation these four rows split in two on each of the two new branches, and a third row is added to each in the second fenestrule after forking. This observation is in agreement with Roger's statement that "the typical number of ranges is three when the central row forms the flat median summit of the branch. In this case the number is increased to four shortly before bifurcating."

Comparison of the measured features on the specimens of *P. elliptica* from the South Bend limestone from near Garnett with the corresponding data of *P. ellip-*

TABLE 6.—*Stratigraphic Distribution and Characters of Bryozoa of the* Polypora elliptica *(s. s.) Group*

Horizon and locality	Species	Branches		Fenestrules		Zooecia		
		Width in mm.	Number per 10 mm.	Size in mm.	Number in 10 mm.	Number in 5 mm.	Number per fenestrule	Number of rows
Bitaoeni, Permian Kampong Apna, Timor.	*P. tripliseriata* Bassler	(about 0.4)[a]	11–12	0.8×0.5	8–9	(about 16)[a]	4	3
Howard limestone (?), Topeka, Kansas.	*P. elliptica* mut. *β*, Elias	0.45	11.5–13	0.7×0.35	9.5–*10*	*19*–19.5	4	3–4 (2–4)
Base Topeka limestone, Shawnee group, Elk Co., Kansas.	*P. elliptica* mut. *β*, Elias	0.4–0.45	11–14	0.7×0.35	9–*10*	18–19	4	*3* (2–4)
Deer Creek limestone, near Topeka, Kansas.	*P. elliptica* mut. *β*, Elias	0.4	13–14	0.7×0.35	9–10	19–19.5	3.5–4	*3* (2–4)
Kereford limestone, Oread formation, Douglas Co., Kansas.	*P. elliptica s.s.*	0.04	14–16	0.6×0.3	11–12	19–20	3–5	3 (2–4)
South Bend limestone, Stanton formation, near Garnett, Kansas.	*P. elliptica* mut. *α*, Elias	0.4	15–16	0.5×0.3	14	20	*3*–4	*3* (2–4)
Drum limestone, Independence, Kansas.	*P. elliptica* mut. *α*, Elias	0.3–0.5	15–16	0.5×0.2	13–14	20	3	*3* (2–4)
"Upper Coal Measures," Kansas and Missouri.	*P. elliptica* Rogers (type)[c]	0.4–0.5	14–16	0.6×0.3	10–12	(about 18[b])	3–4[b]	*3* (2–4)

[a] Measured on photograph fig. 16, pl. 242, Bassler, 1929.
[b] Measured on sketch fig. 2, pl. 4, Rogers, 1900.
[c] The exact horizon of the type is unknown; probably Oread limestone, Shawnee group.

tica from the Drum limestone described by Sayre proves their identity. I indicate them as early mutation α of *P. elliptica* Rogers and select the Drum limestone specimen (Sayre, 1930, pl. 3, figs. 2–4, type No. 8, Kansas Univ. coll.) the holotype of the mutation.

Forms similar to POLYPORA ELLIPTICA

The fact that *P. elliptica* in its very broad conception is a "composite species" was emphasized by Dr. Condra in a letter (March 14, 1932) to me stating that

> it will be necessary to study the original types of these composite species, so-called, before the stratigraphic distribution of any one of them can be determined. This will require very close study in order to establish the features which have specific importance. For example, several forms are now included under *Polypora elliptica* Rogers and one of these forms must ultimately represent the species. What I mean is that the elliptical form of the fenestrules does not have specific importance and that one or more of the other features must be selected to represent the species.

Comparative study of *P. elliptica* and numerous related forms convinced me that it is possible and practicable to differentiate a group comprising this species (*sensu stricto*) and its mutations from several varieties which are distinguished from *P. elliptica* in some essential features. These varieties will now be discussed.

In *P. elliptica* the nodes are located symmetrically opposite the intervals between the central zooecia, so that each central zooecium is surrounded by four nodes. This arrangement of nodes at once distinguishes *P. elliptica* (*s. s.*) from the specimens with a central row of nodes disposed along a prominent carina, which, according to Condra (1903, p. 71) were "identified by Mr. Rogers as *P. elliptica*." I suggest the removal of this form, which may be temporarily designated as *Polypora elliptica* var. *A*, Elias, from *P. elliptica* (*s. s.*). The specimen illustrated by Condra on pl. 11, figs. 10 and 11, represents this type of zoarium.

Besides *P. elliptica* var. *A*, with prominent central (true) carina, the form which Condra designated as var. *formosa* must be differentiated from *P. elliptica*. The main characteristic features of this form are the subtriangular shape of the branches in cross-section and the rhombic fenestrules "in young specimens." In adult zoaria the fenestrules are subquadrangular to subcircular, while in *P. elliptica* the fenestrules are elliptical, from which feature it has been named *elliptica*. The variety *formosa* is illustrated by Condra (1903) on pl. 12, figs. 5–13. In Kansas I observed this variety in the Topeka limestone at Topeka, Kans. (Kansas Univ. Coll., no. 378).

The third form to be differentiated from *P. elliptica* is *P. spinulifera* Ulrich with normally four, instead of three rows of zooecia, and five to six rows of zooecia, instead of four (in *P. elliptica*), below bifurcations. This species was observed together with typical *P. elliptica* and many other species of Bryozoa on a single slab from the Kereford limestone (top of Oread limestone formation) collected by Mr. A. Bridwell, of Baldwin, Kans.

Condra (1903, p. 72, pl. 11, figs. 10 and 11) differentiated, but did not name, still another *P. elliptica*-like form which is "yet more unlike typical specimens of the species." It has two to six rows of zooecia, "bearing a carina where there are two ranges of zooecia." I have not as yet observed such a form in the collections from Kansas.

With limitation of *P. elliptica* to the restricted sense and with the separation from it of various related species as discussed above (see also varieties from the Big Blue series described below), I found that its known stratigraphic range in Kansas and adjacent territory is comparatively narrow, and that the form is apparently not represented at all in the Big Blue series. Even when considered in a broad sense, the form, while very common in the rocks of the Missouri and Virgil series, is comparatively rare in the higher beds (Big Blue). Beede and Rogers (1908, p. 376) register only one occurrence of *P. elliptica* above the Howard

limestone of the Wabaunsee group. This is in the Neva limestone.

In the collection of Bryozoa from the Neva limestone at Burbank, Okla. (Kansas Univ. coll., no. 989), there is an unusually stout variety of *P. elliptica* type of zoarium, and the same variety has been frequently collected from the Fort Riley limestone at several localities in Kansas. This Big Blue form is at once distinguished from *P. elliptica* (*s. s.*) and mutations by its very stout zoarium, the stoutness being its regular feature and not merely the result of additional calcareous encrustation that is occasionally observed on portions of the zoaria of fenestrate bryozoans; this additional encrustation has a smooth surface and obliterates all external features of the zoarium such as granulated surface, zooecia and even nodes. In the stout form of the Big Blue series all these features are normally and clearly developed. The stout form has very thick branches (one and one-half times as thick as wide) and its nodes, which surround the zooecia of the central row, are very massive, the zooecia being deeply sunk in between. Besides these ordinary nodes the form has also massive node-like elevations on the dissepiments, usually two on each dissepiment. These elevations make the dissepiments nearly as thick as the branches. The following are average data measured on the specimens from the Fort Riley limestone (Kansas Univ. coll., no. 860). Branches, 15 per 10 mm.; fenestrules, 8 per 10 mm.; zooecia, 20 per 5 mm. (3 per fenestrule). The spacing of branches and zooecia is like that in *P. elliptica* mut. α, from the Missouri series, while the fenestrules are as long as in *P. tripliseriata* from the Permian of Timor.

All in all, the Big Blue form is distinct enough from *P. elliptica* and its mutation to regard it as a new form. I designate it temporarily as *P. elliptica* var. *B.*

Still another form somewhat similar to *P. elliptica* has been observed by me in the Schroyer limestone of the Wreford formation of the Big Blue series; this species has only two rows of zooecia increasing to three at bifurcation.

Condra (1903, p. 72) records the occurrence of *P. elliptica* in the Big Blue series at Blue Springs, Nebr., but he does not illustrate the form from this locality and does not say to which variety among those recognized by him the Blue Springs form belongs. The exposures at Blue Springs, as briefly mentioned by Condra and Upp (1931, pp. 42, 43), and subsequently examined by me, belong to the Barneston formation (Florence limestone-Fort Riley limestone). In view of the widespread occurrence of the above-described stout form *P. elliptica* var. *B* in the Fort Riley limestone, it is probable that the recorded *P. elliptica* at Blue Springs belongs to this variety. Considering all these observations we may conclude that *P. elliptica* (*s. s.*) either is not present in the rocks of the Big Blue series at all, or is rare, as it has not been definitely recorded from them as yet.

From this it does not necessarily follow that the true *P. elliptica* (*s. s.*), or rather a form which may be recognized as its direct descendant, did not survive into Autuno-Permian time in the Mid-Continent or elsewhere in the world. It is interesting to observe that in *P. tripliseriata* Bassler from the Bitaoeni Permian rocks of Timor we apparently have a perfect replica of the North American *P. elliptica* (*s. s.*), except that the Timor species has a slightly coarser zoarium, there being fewer branches and dissepiments per given space in *P. tripliseriata* than in *P. elliptica* (*s. s.*) as described by Rogers.

POLYPORA TRIPLISERIATA Bassler

Polypora tripliseriata BASSLER, R. S., *1929*, Permian Bryozoa of Timor, p. 79, pl. 242 (18), figs. 14–16.

The following is a complete quotation from the description of *P. tripliseriata* by Bassler (1929, p. 79) (italics mine).

Type specimen a small, worn frond attached to limestone and exposing the reverse side. The preservation is good enough, however, to show that the frond is composed of

branches sometimes as wide as the fenestrules connected by short and almost equally thick dissepiments. The measurements are as follows: 11 to 12 branches in 10 mm. and measuring longitudinally 8 to 9 fenestrules in the same space with an average fenestrule 0.8 mm. by 0.5 mm. A thin section cutting the obverse side shows the same characters for the celluliferous space where the branches are noted to bear three rows of rounded apertures longitudinally arranged with 4 in the length of a fenestrule. *The rows of apertures are marked off by longitudinal threads* composed of granular material and bearing a spine at regular intervals equal in numbers to the zooecia. The zooecia usually alternate in position and most frequently the spines are opposite each other, thus giving the aspect of each zooecium being guarded by 4 spines so placed as to form a quadrangle about it. The tissue between the zooecial apertures is composed of fine, but distinctly marked closely arranged granules. The small fenestrules and the comparatively thick branches with three rows of apertures separated by longitudinal lines bearing regularly spaced spines readily distinguish this species.

Occurrence.—Rare at Kampong Apna. Collection Molengraaff.

It is important to notice that besides having zooecia arranged in the same number of rows and in the same relation to fenestrules, and spines surrounding central zooecia in fours, as in *P. elliptica* of North America, the Timor species possesses also what Bassler described as "longitudinal lines" or "longitudinal threads" separating the rows of zooecia. His description and the photograph (pl. 242, fig. 16) leave no doubt that in *P. tripliseriata* we observe the same peculiar structure between the rows of zooecia as is developed in *P. elliptica*. The species from Timor differs from this American form only in having branches, dissepiments and zooecia somewhat more distantly spaced. Realization of this relation raised the question as to whether or not the American forms of *P. elliptica* from different horizons show any evolutionary changes leading toward the peculiarities observed in *P. tripliseriata* of Timor.

POLYPORA ELLIPTICA Rogers mut. β Elias
(late mutation)

Examination of *P. elliptica* from the Oread, Deer Creek, Topeka and Howard limestones of the Shawnee and Wabaunsee groups proves that the forms from these formations show clearly progressive changes in the direction of *P. tripliseriata*. The data obtained through measurement of these forms are entered in Table 6. This shows that while the specimens of *P. elliptica* from the South Bend limestone above the *Walchia*-bearing shale are indistinguishable from *P. elliptica* from the Drum limestone of the Missouri series, *P. elliptica* from the Kereford limestone of the Shawnee is different from it, and still more different are the forms from the higher beds of the Shawnee and Wabaunsee groups of the Virgil series. These latter forms show the transitional character from *P. elliptica* of the Missouri series to *P. tripliseriata* of Timor. The evolutionary series is illustrated by fig. 2, in which sketches of fenestrules based on average measurements are arranged in stratigraphic order. The evolutionary change in this series is of the same general character as detected in the above described *Fenestrellina mimica* group. Here, too, the zoarium shows homogeneous expansion with advance of geologic time, the distances between the branches, fenestrules and zooecia being gradually increased from the smallest in the *P. elliptica* of the Missouri series to the largest in the *P. tripliseriata* of the Permian of Timor.

In view of the closest similarity of *P. elliptica* from the Kereford limestone to *P. elliptica* as originally described and illustrated by Rogers, the form from the Kereford is identified as *P. elliptica* (*s. s.*). The forms from the Drum and from the South Bend limestone are here designated as *P. elliptica* early mutation α, Elias. The specimens from the Deer Creek and the higher beds of the Shawnee and Wabaunsee are designated as *P. elliptica* late mut. β, Elias. For the type is taken the specimen of the Kansas Univ., coll. no. 8333, Howard (?) limestone, Wabaunsee group, exposed at Topeka, Kans.

APPENDIX I

Late Paleozoic Species of Fenestrellina *from North America and Timor Grouped According to the Nature of Ornamentation*

Nodes absent
- Carina absent
  - Depression in place of carina
    - *F. sevillensis* (Ulrich), L. Penn.
  - Carina obsolete, or very faint, or replaced by fine nodes
    - *F. limitaris* (Ulrich), Miss.
    - *F. ovatipora* (Rogers), U. Penn.
    - *F. moorei* (Sayre), U. Penn. (nodes small, no carina)
    - *F. gratiosa* (Moore), U. Penn.
    - *F. rottiensis* (Bassler), Perm., Timor
- Carina present, faint
  - *F. filistriata* (Ulrich), Miss.
  - *F. elevatipora* (Ulrich), Miss.
  - *F. perminuta* (Ulrich), L. Penn.
- Carina present, strong
  - *F. missouriensis* (Rogers), M. Penn.
  - *F. garnettensis* Elias, M. Penn.
  - *F. placida* (Moore), U. Penn.
  - *F. cyclofenestrata* (Condra), L. Perm.
  - *F. subrudis* (Condra) (? Miss., ? L. Perm.)
  - *F. pulchradorsalis* (Bassler), Perm., Timor

Nodes in one row
- Carina absent
  - *F. cingulata* (Ulrich), Miss.
  - *F. cestriensis* (Ulrich), Miss.
  - *F. mimica* (Ulrich), L. Penn.
  - *F. condrai* (Moore), U. Penn.
  - *F. moorei* (Sayre), U. Penn.
- Carina present
  - Nodes faint
    - *F. burlingtonensis* (Ulrich), Miss.
    - *F. tenax* (Ulrich), Miss.
    - *F. delicatula* (Ulrich), L. Penn.
    - *F. latericrescens* (Bassler), Perm., Timor
  - Nodes strong
    - *F. rudis* (Ulrich), Miss.
    - *F. regalis* (Ulrich), Miss.
    - *F. compressa* (Ulrich), Miss.
    - *F. multispinosa* (Ulrich), Miss.
    - *F. triserialis* (Ulrich), Miss.
    - *F. serratula* (Ulrich), Miss.
    - *F. exigua* (Ulrich), Miss.
    - *F. flexuosa* (Ulrich), Miss.
    - *F. cestriensis* (Ulrich), Miss.
    - *F. funicula* (Ulrich), Miss.
    - *F. modesta* (Ulrich), L. Penn. (also U. Penn.?)
    - *F. wortheni* (Ulrich), L. Penn.
    - *F. mimica* (Ulrich), L. Penn.
    - *F. conradi* (Ulrich), Penn.
    - *F. inaequalis* (Ulrich), Penn.
    - *F. limbata* (Foerste), Penn.
    - *F. limbata* var. *remota* (Foerste), Penn.
    - *F. hexagonalis* (Rogers), U. Penn.
    - *F. dentata* (Rogers), U. Penn.
    - *F. kansasensis* (Rogers), U. Penn.
    - *F. mimica* mut. *latirama* (Sayre), M. Penn.
    - *F. spinacristata* (Moore), U. Penn.
    - *F. mimica* mut. *raymondi* Elias (var. *texana*, Moore), U. Penn.
    - *F. mimica* mut. *wellsi* Elias, U. Penn.
    - *F. pectinis* (Moore), U. Penn.
    - *F. plummerae* (Moore), U. Penn.
    - *F. spinulifera* (Moore), U. Penn.
    - *F. spinulifera* var. *pustulosa* (Moore), U. Penn.
    - *F. minuta* (Moore), U. Penn.
    - *F. nodulosa* (Moore), U. Penn.
    - *F. nodulosa* var. *minor* (Moore), U. Penn.
    - *F. perelegans* (Meek) (L. Perm?)
    - *F. spinulosa* (Condra), L. Perm.
    - *F. conradi* var. (Condra), L. Perm.
    - *F. parvipora* (Condra), L. Perm.
    - *F. gracilis* (Condra), L. Perm.
    - *F. polyporoides* (Condra), L. Perm.
    - *F. orientalis* (Bassler), Perm., Timor
    - *F. basleoensis* (Bassler), Perm., Timor
    - *F. parviuscula* (Bassler), Perm., Timor
    - *F. aspratilis* (Bassler), Perm., Timor
    - *F. girtyi* Elias (*spinulosa?* Girty), U. Perm.

Nodes in two rows
- Carina absent
  - *F. kukaensis* (Bassler), Perm., Timor
- Carina present
  - *F. bispinulata* (Moore), L. Penn.
  - *F. geminanoda* (Moore), U. Penn.-L. Perm.
  - *F. binodata* (Condra), U. Penn.-L. Perm.
  - *F. conradi-compactilis* (Condra), U. Penn.-L. Perm.

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JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 4, PP. 335–336, JUNE, 1937

A NEW SCORPION FROM THE PENNSYLVANIAN *WALCHIA* BEDS NEAR GARNETT, KANSAS

MAXIM K. ELIAS

ABSTRACT

The new *Mazonia hungerfordi*, from the *Walchia*-bearing shale in the upper part of the Lansing group, Pennsylvanian, near Garnett, Kans., is the second species of this Pennsylvanian genus of scorpions to be described. It has the following important features not preserved in the genotype: five segments and poison gland in post-abdomen, and spurs on legs.

A fairly well-preserved scorpion has been found in the shale with *Walchia* and other interesting flora and fauna, 4 miles west and 5 miles north of Garnett, Kans. The remains are in the form of semitransparent brown tissue apparently representing the flattened outer skeleton of the scorpion. Part of this tissue stuck to one side of the split rock and part to the other. The impression of the tissue on the rock is very faint, but nevertheless is strong enough at the cephalo-thorax to leave on the rock the outline of eye-sockets, which are also recognizable on the tissue itself. The scorpion was found in the Rock Lake shale, Stanton limestone formation, Lansing group, Missouri series, Pennsylvanian. Following is a description of this species, which is named in honor of Dr. H. B. Hungerford of the University of Kansas.

Genus MAZONIA, Meek and Worthen (1868)

MAZONIA HUNGERFORDI Elias, n. sp.
Figure 3*n* (see paper on Bryozoans)

Mazonia hungerfordi ELIAS, *1936*, Jour. Geology, vol. 44, no. 1, figs. 6–12 (p. 13) and figs. 8–11 (p. 15).

The scorpion from the Garnett locality is referred to Meek and Worthen's genus *Mazonia* on the ground of the peculiar setting of the medial eyes (lateral eyes are undeveloped) close to the anterior edge of the cephalo-thorax (carapace), which is an important diagnostic character of *Mazonia woodiana*. Some American *Eoscorpius* have middle eyes placed also close to the anterior edge of the cephalothorax, but in these cases the edge itself is straight, and not subangular, as in *Mazonia*.

Meek and Worthen observed that in *Mazonia woodiana* "there appear to be at least seven segments (in abdomen), with just space enough between the anterior, or seventh one seen, and the cephalo-thorax, for an eighth one (Pocock, 1911, p. 11; Fritsch, 1904, not seen by me). Pocock remarks that this species has "either a segmental carapace or eight dorsal shields" or "possibly, indeed, nine, according to Fritsch." Petrunkevitch, who reexamined the type of *Mazonia*, concludes that if its abdomen has been composed of eight segments, and

> if *Mazonia* is a scorpion, the cauda (or post-abdomen) must have been only of four segments, since the number of segments in all known scorpions is twelve. On examining the specimen, I, too, came to the conclusion that the last segment shows all semblance of the seventh abdominal tergite of a normal scorpion. There is also no doubt that behind the cephalothorax is a segment. It may be clearly seen even on the photograph. The two alternatives would be therefore that this segment represents the last thoracic segment which remained free as is the case in Solifugae and Palpigradi or the pregenital segment characteristic of embryos. Neither of these alternatives, however, finds support in the structure of either extinct or recent scorpions. One could rather conceive a scorpion with six abdominal and six caudal segments, as that would be more in agreement with some eurypterids and

Xiphosura. Perhaps *Mazonia* had after all no distinct separation between abdomen and cauda, and the last four segments were small.

If the arachnid from the *Walchia* locality is referable to *Mazonia*, the presence in it of the complete number (5) of segments in the cauda eliminates this latter suggestion. The problem shifts, therefore, to the necessity of some explanation of the occurrence of an extra segment, as it were, behind the cephalo-thorax in *M. woodiana*. Unfortunately, *M. hungerfordi* does not throw light on this problem because its remains show indistinct segmentation due to poor preservation of this part of the body. The character of preservation of this part seems to be similar to that of *Eoscorpius daniels* Petrunkevitch (1914, p. 44) in which "the presence of transverse lines which represent probably artificial folding of the skin" prevents counting of the number of abdominal tergites.

Specifically, *M. hungerfordi* differs from the genotype by somewhat differently oriented eyes, by general larger size, and by the different shape of the posterior (seventh) abdominal segment. In *M. hungerfordi* it is nearly two times as wide as long, while in *M. woodiana* it is about as wide as long. The long and slender pedipalp of *M. woodiana* is possibly another specific distinction of this species not duplicated in the species from Garnett, but this appendage is much crushed in the latter and its features cannot be observed. On the other hand, the species from Garnett shows preservation of the following parts, which are missed in the genotype from Mazon Creek: apical portion of pedipalp, one well preserved and a few less preserved legs and complete cauda. An important additional feature, which is preserved only on the species from Garnett, is development of numerous tibial spurs.

Occurrence and type.—Rock Lake shale member of the Stanton limestone, Lansing group, Missouri series, Carboniferous (Pennsylvanian subsystem), near Garnett, Anderson County, Kans. Holotype, Univ. Kans. coll.

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JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 4, PP. 337–346, TEXT FIGS. 1–4,
JUNE, 1937

EVOLUTIONARY TENDENCIES IN AMERICAN CARBONIFEROUS TRILOBITES

J. MARVIN WELLER

ABSTRACT

The genus *Phillipsia*, restricted, is considered to typify the primitive form from which most other Carboniferous trilobites have been derived. Evolution produced a glabella expanded in front, and larger eyes. In different lines of descent the flat marginal border anterior to the glabella was lost, a preoccipital lobe was developed, and the basal furrows were straightened. The most complete series of evolutionary changes, however, are exhibited by the pygidia and involve the development of (1) a sharply differentiated flange, (2) an elevated axis, followed in one line by (3) flattening of the axial crest and geniculation of the pleural lobes. There was also a general increase in the number of pygidial segments, particularly in the axis, which resulted in increasing disparity between the number of pleural and axial segments. In *Ditomopyge* progressive decrease in length of genal spines is traced from lower Pennsylvanian to Lower Permian species.

The genus *Phillipsia* Portlock, as recently restricted (Weller, 1936), may be considered to typify the primitive and generalized form from which most of the other Carboniferous trilobites known in America have been derived. Although the other genera may not necessarily have descended from *Phillipsia* itself, this genus appears to be closely similar to the common ancestral form.

The primitive characters of *Phillipsia* which are most significant in an evolutionary consideration of the Carboniferous trilobites, and which in succeeding genera have undergone marked changes, include shape and structure of glabella, size of eyes, nature of anterior cephalic border, and form of pygidium. The form of these various parts, as combined in *Phillipsia*, more closely resembles the American Devonian representatives of the Proetidae than the later Carboniferous members of the family. Variations in the development of these parts singly and in combination furnish the basis for my classification of the American Carboniferous trilobites into eight genera (Weller, 1936) whose ranges are shown in Table 1.

TABLE 1.—*Ranges of Carboniferous Trilobite Genera*
(See fig. 1)

	Kinderhook	Osage	Meramec	Chester	Morrow	Des Moines	Missouri	Virgil	L. Permian
Phillipsia	X	—	—	—	—	—	—	—	—
Exochops	—	X	—	—	—	—	—	—	—
Griffithides	X	X	X	?	—	—	—	—	—
Kaskia	—	—	X	X	—	—	—	—	—
Paladin	—	—	—	X	X	—	—	—	—
Ditomopyge	—	—	—	—	X	X	X	X	X
Sevillia	—	—	—	—	—	X	—	—	—
Ameura	—	—	—	—	—	X	X	X	X

DERIVATION OF THE GLABELLA OF CARBONIFEROUS TRILOBITES

The principal type of proetid glabella occurring in the Devonian formations is long and it tapers rather uniformly forward, thus differing from any known in the Mississippian rocks. This type of glabella was apparently modified by expansion of its anterior part to produce the nearly straight and parallel-sided glabella of *Phillipsia*. Continued modification in this direction gave rise in later genera to the glabella bounded by more or less sinuous sides and expanded in front of the eyes, so that this is commonly its widest part, which is so characteristic of the Carboniferous trilobites. Evolution also proceeded in the opposite direction, however, and decrease in the length of the glabella and the resulting recession of the glabella from the frontal border of the cephalon gave rise to *Brachymetopus* and allied forms. Neither the phillipsid nor brachymetopid type of glabella survived the Lower Mississippian. Such changes in size and shape of the glabella probably resulted from changes in the development of organs of the head. If trilobite anatomy were better understood, such changes might be correlated with changing aptitudes of greater or lesser survival value.

ANTERIOR MARGIN OF CEPHALON

A flat marginal band anterior to the glabella is characteristic of practically all Devonian Proetidae. This structure also is present in *Phillipsia*, *Palladin*, *Sevillia* and *Ameura* but is lacking in *Exochops*, *Griffithides*, *Kaskia* and *Ditomopyge* (see fig. 1). It is certainly a primitive character in this family, because immature specimens of both *Kaskia* and *Ditomopyge* have been observed to possess flat margins that are later lost, as maturity is attained. The evolutionary advance that resulted in the loss of this margin occurred, however, at different times in different groups of the Proetidae and forms retaining the marginal band persisted to Middle Permian time. The disappearance of the marginal band apparently resulted from continued increase in size of the forward part of the glabella.

BASAL FURROWS

Like most Devonian forms, the basal furrows of *Phillipsia* are strongly curved, and similar furrows persist in the much younger genus *Ameura* and possibly also *Sevillia*. Other Carboniferous forms possess basal furrows whose main, central, deeply impressed parts are nearly if not quite straight.

PREOCCIPITAL LOBE

The development of a preoccipital lobe in the glabellae of *Ditomopyge* and *Sevillia* appears to be an example of parallel contemporaneous evolution. Faint suggestions of such a lobe are present in some of the later representatives of *Kaskia*, but in this line of the Proetidae it was not fully developed until *Ditomopyge* appeared in early Pennsylvanian time. The incomplete development of a preoccipital lobe had also occurred

earlier, in the Devonian period, and is best marked in *Schizoproetus*, but no descendants of these genera are known to have survived into Mississippian time.

EYES

Conspicuous enlargement of the eyes occurred in the Proetidae in the middle part of Mississippian time.

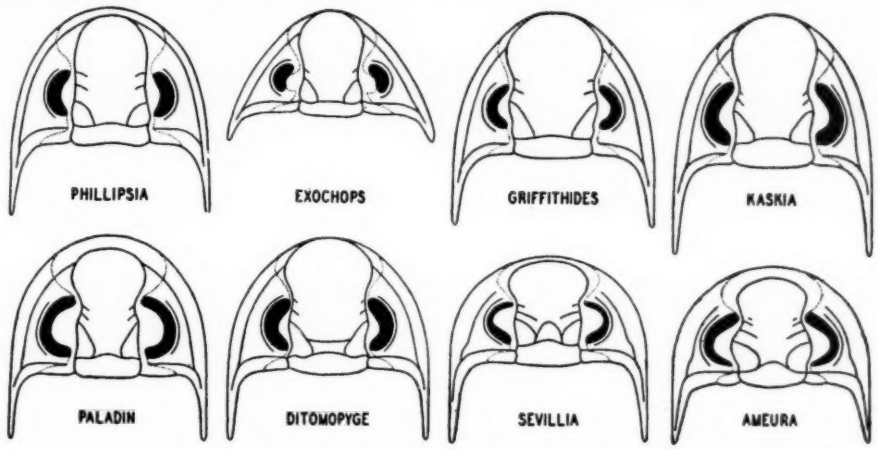

FIG. 1—Cephalic structure of American Carboniferous trilobite genera.

The eyes of *Phillipsia*, *Griffithides* and *Exochops* are only about half the size of the eyes of most of the later Carboniferous genera. Smaller eyes are, however, again characteristic of most Mid-Permian trilobites.

PYGIDIA

Although trilobite pygidia have generally been considered to possess small value in the classification of these organisms or the identification of genera, it is the pygidia of the Carboniferous species that present a more complete and convincing example of evolutionary advancement than any other part of these fossils.

Structure of Pygidium.—The trilobite pygidium consists of a series of coalesced segments similar to the free segments of the thorax. The pleural segments generally recognized in the pygidia of Carboniferous trilobites, however, do not correspond exactly to the original segments of which the pygidia are composed. The conspicuous pleural furrows are the lines of division, not between the original pleura, but between two parts of the individual pleura which correspond to the anterior underlapping and posterior overlapping portions of the free thoracic segments (fig. 2). The actual divisions between the original segments, if separately shown, occur as shallow subsidiary furrows slightly anterior to the generally stronger principal pleural furrows. Where observable, the subsidiary furrows of the pygidial pleural lobes extend nearly to the periphery, but the principal furrows are shorter and, like the longitudinal furrows of the free

thoracic pleura, become obsolete at a greater distance inside the margin.

Types of Pygidia.—The pygidia of most early Mississippian trilobites which traces of pleural segmentation extend faintly only in the anterior region, opposite the first two or three pleura (Tables 3 and 4). Examina-

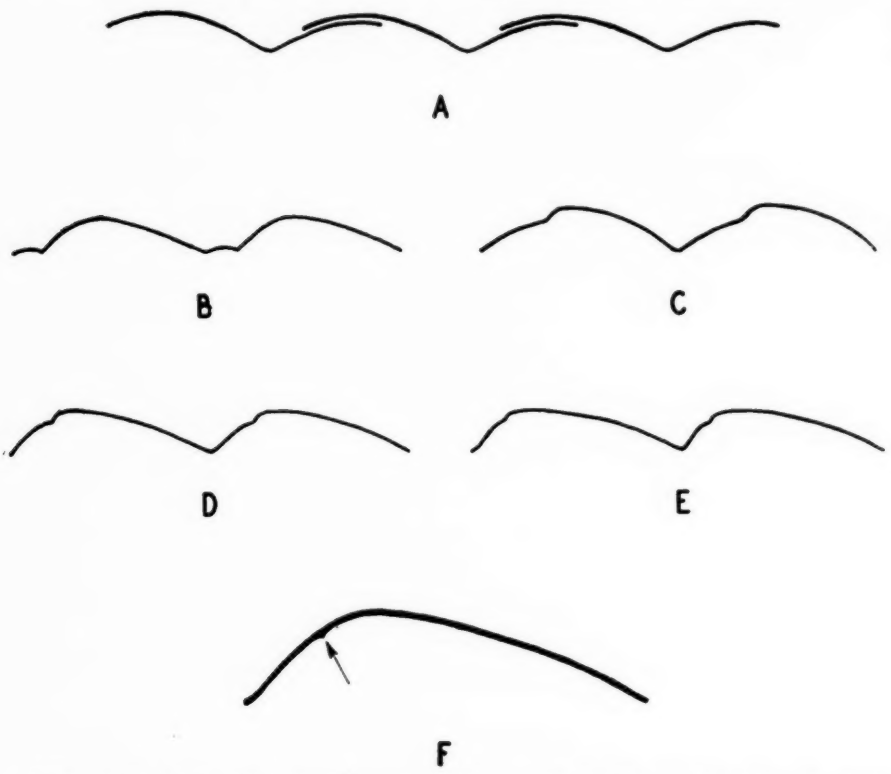

FIG. 2—Structure of pygidial pleural segmentation. *A*, Transverse section through pleural portions of three free thoracic segments showing overlap. *B*, Transverse section through two pygidial pleura of *Phillipsia sampsoni* showing relations of principal and subsidiary furrows. *C*, *D*, and *E*, Similar sections of *Proetides insignis*, *Kaskia chesterensis*, and *Ditomopyge olsoni* showing relations of principal and subsidiary furrows and increasing asymmetry of pleura. *F*, Similar section through a single pygidial pleuron of *Ameura major* showing thickening of the test which marks position of subsidiary furrow.

possess poorly-defined flanges onto which the pleural segmentation extends more or less strongly. This segmentation is continued posteriorly even directly behind the axis. In middle Mississippian time this type of pygidium gave place to one with a distinct non-undulating flange upon tion of the latter type of pygidium shows that the first few principal furrows end, like all of the later ones, at the inner edge of the flange, but that the subsidiary furrows, preserved only on the anterior pleura, extend beyond them and occupy the troughs of the faint undulations that

are present only on this part of the flange. This relationship indicates that the obvious pleural segmentation is determined by the principal furrows and that, in contrast, the continuation of the pleural ridges onto the flange is determined by the subsidiary furrows. Therefore, the development of an even, non-undulating pygidial flange is dependent on the obsolescence of the subsidiary furrows, and because these furrows mark the primary divisions of which the pygidium is composed, their degeneration is an evolutionary advance.

pleural furrows, as shown in Figure 2, B and C. Later Carboniferous species are, so far as known, of the latter type, and with the passage of time there was a general tendency toward greater asymmetry in the cross-section of the pygidial pleura, as shown in Figure 2, C, D, and E. In all of these the subsidiary furrows, if present at all, are preserved only on the first few anterior segments, and the perfection of their preservation varies greatly even between different individuals of the same species. *Ameura* is the only Carboniferous genus in which these furrows are totally absent, but their positions are indicated on internal casts by faint grooves produced by slight thickening of the test, as is shown in Figure 2, F.

TABLE 3.—*Summary of the Pygidial Characters of Carboniferous Trilobite Genera* (See figs. 2 and 3.)

	Flange		Axis		
	Poorly Defined	Distinct	Low	Elevated	Trapezoidal
Phillipsia	X	—	X	—	—
Griffithides	X	—	X	X	—
Exochops	X	—	—	X	—
Kaskia	—	X	X	X	—
Paladin	—	X	X	X	—
Sevillia	—	X	—	X	—
Ameura	—	X	—	X	—
Ditomopyge	—	X	—	X	X

TABLE 4.—*Stratigraphic Occurrence of the Four Principal Types of Carboniferous Trilobite Pygidia* (See fig. 3)

	A	B	C	D
Kinderhook	X	—	—	—
Osage	X	—	—	—
Meramec	—	X	—	—
Chester	—	X	X	—
Morrow	—	X	—	X
Des Moines	—	—	X	X
Missouri	—	—	X	X
Virgil	—	—	X	—
L. Permian	—	—	X	—

Kinderhook species exhibit two types of arrangement of the pygidial

Both *Phillipsia* and *Griffithides* possess poorly defined pygidial flanges of the primitive type described above. They are also characterized by a primitive type of pygidial axis, which is comparatively low, with gently sloping sides and fairly uniform transverse curvature

(fig. 3, A). Similar primitive axes are also present in some species of *Kaskia* and *Paladin*, in combination with even, well marked flanges (fig. 3, B). Other species of these latter genera, however, bear axes which are considerably higher in proportion, and bounded by steeply sloping flattened sides (fig. 3, C). Such alteration of both flange and axis has produced or less well marked geniculation of the pleural lobes and a steepening of the outer portions of the pleura in their descent to the flange (fig. 3, D).

Increase in Pygidial Segmentation.—In the American Carboniferous Proetidae there is a general tendency toward increase in the number of pygidial segments from lower to higher horizons. Although this is

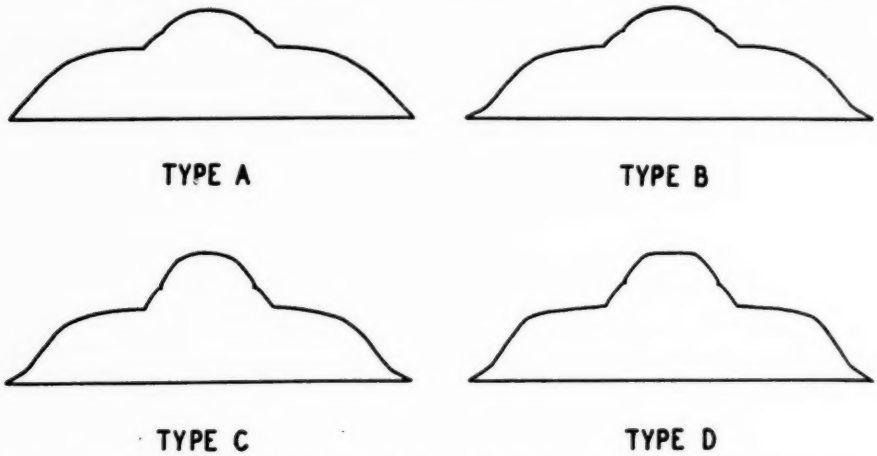

FIG. 3—Transverse profiles illustrating the four principal types of Carboniferous pygidia.

pygidia quite easily distinguishable from most Kinderhook pygidia. This type of pygidium is also characteristic of *Sevillia*, in the lower Pennsylvanian, and *Ameura*, which continues into strata of Lower Permian age (Table 3).

The pygidium of *Exochops* combines the primitive type of flange (fig. 3, A) and the advanced type of elevated axis (fig. 3, C).

Further modification of the pygidial axis occurred in *Ditomopyge* with a flattening of the crest, so that a trapezoidal cross-section is attained. This is accompanied by more

true for the family as a whole, it is best exhibited within the genera *Ditomopyge* and *Ameura*. In the earliest species of *Ditomopyge* there are 7 and 12 segments in the pleural lobes and axis, respectively, and in the latest 9 and 15. The earliest species of *Ameura* possess 9 and 16, and the latest, 12 and 22 segments in these same parts. None of these species have yet been described.

As the foregoing figures show, there is considerable disparity between the number of pleural and axial segments, the number of pleural segments being less than the number

of axial segments. This disparity is comparatively small in a number of Kinderhook species, but it increases rather uniformly in successively younger strata, as shown in Tables 5 and 6.

Table 5 shows ratios of pleural to axial segments in the pygidia of American Carboniferous trilobites. The figures following "Kinderhook" refer to species probably belonging (Walter), is not in line with the others in either table. The ratios in Table 6 for the Des Moines, Missouri, and Lower Permian trilobites are higher than their respective stratigraphic positions would suggest, principally because of the occurrence of species of *Ameura* at these horizons. The ratios for *Ameura* are consistently higher than ratios for *Ditomopyge* from similar horizons.

TABLE 5.—*Ratios of Pleural to Axial Segments in the Pygidia of American Carboniferous Trilobites*

	Number of Species	Pleural Segments	Axial Segments	Ratio	Average Ratio
"Kinderhook"	7	7–16	8–17	.792–.885	.838
Griffithides	5	10–11	13–16	.678–.769	.759
Exochops	1	10–11	14–15	.725	.725
Kaskia (U. Miss.)	2	10–12	14–17	.714–.716	.715
Ditomopyge (L. Penn.)	2	7– 9	11–12	.697–.708	.702
Kaskia (M. Miss.)	1	8– 9	13–14	.630	.630
Paladin	5	7– 9	14–16	.562–.690	.622
Sevillia	2	9–11	16–18	.576–.600	.588
Ditomopyge (M. Penn.)	9	6– 8	10–13	.461–.660	.586
Ameura	5	9–14	16–25	.545–.595	.566
Ditomopyge (U. Penn.)	2	7– 9	13–15	.519–.585	.552
Anisopyge	1	8	28–30	.266–.285	.275

to three genera that are not differentiated. *Kaskia* is divided into two parts, and *Ditomopyge* into three parts on a stratigraphic basis. One of the two species of the latter, listed as upper Pennsylvanian, is from the Lower Permian. At the end of the table is included *Anisopyge* from the Permian of the Southwest, to show the ultimate known limit in the unequal development of these parts.

Table 6 shows ratios of pleural to axial segments in the pygidia of American Carboniferous trilobites, arranged stratigraphically. The one Meramec species, *Kaskia wilsoni*

The great majority of Devonian Proetidae possess ten thoracic segments; almost all Carboniferous species possess nine. Such reduction is exhibited not only by the Proetidae but also by other groups of trilobites. Such reduction in the number of thoracic segments was paralleled, in a general way, throughout the Paleozoic era by an increase in the number of segments incorporated in the pygidium. As the thorax was simplified, the pygidium became more complex. There appears, however, to have been no close correlation between these two processes; as a segment

was lost from the thorax it was not necessarily added to the pygidium. The Carboniferous species show conclusively that one of these processes could be active without the other.

In the Carboniferous Proetidae the number of pygidial segments progressively increases without corresponding decrease in the number of thoracic segments. Here progress is indicated by an increase in the number of similar parts. If we may assume, as seems reasonable, that variation in the number of pygidial segments was not several times reversed, the number of pygidial segments may be employed as one line of evidence bearing upon the genetic relationships of the various species and genera. Certain conclusions based upon this assumption appear to be substantiated by other evidence.

TABLE 6.—*Ratios of Pleural to Axial Segments in the Pygidia of American Carboniferous Trilobites Arranged Stratigraphically*

	Number of Species	Average Ratio
Kinderhook	7	.838
Osage	5	.740
Meramec	1	.630
Chester	5	.690
Morrow	4	.525
Des Moines	10	.589
Missouri	7	.579
Virgil	1	.519
Lower Permian	2	.565

Development of Pygidium.—The structure of Carboniferous trilobite pygidia appears to offer evidence in favor of the retroserial growth of these parts. Beecher and others have believed—and their conclusions have been generally accepted—that each segment originated immediately in advance of the telesonic somite and was pushed forward by the appearance of each successive segment, first to form the pygidium, but with further growth and after the pygidium was completed, the anterior segments were freed one by one to form the thorax. If this were the case, the anterior pygidial segments should be the oldest, have experienced the greatest number of moults, and therefore probably retain fewer primitive characters. This is not the case, because it is the anterior pygidial segments that retain the primitive subordinate furrows and are continued by small undulations on the flange. Also the disposition and number of pleural segments suggest a backward crowding from the front rather than a forward crowding from behind. Were the posterior segments the ones last formed, they should be complete even though primitive and small. They are, however, preserved only in the axis.

Restudy of the immature pygidia described by me in 1935 indicates that the disparity in number between pleural and axial segments gradually increased during the adolescent de-

TABLE 7.—*Ratios of Pleural to Axial Segments in a Series of Immature Pygidia of* Ditomopyge olsoni

Jour. Paleontology, vol. 9, p. 507 Fig.	Pleural Segments	Axial Segments	Ratio
4	5	7	.714
5	8	10	.800
6	9	12	.750
7	7	11	.636
8	6	12	.500

velopment of this species as a result of the disappearance of the posterior pleural segments. Table 7 gives the number of segments and ratios for five specimens in the series from the smallest observed pygidium to the smallest pygidium of mature form.

The exact number of segments present in the smaller specimens is somewhat uncertain because of their minute size and somewhat imperfect preservation. It is also possible that these specimens are incomplete, as one or more anterior segments may have been broken away. This would account for the inconsistency of the ratio in specimen 4, which is less than that in specimen 5. The decrease in number of pleural segments in specimens 6, 7, and 8, which are believed to be complete, is, however, quite clear. Thus the immature specimens of *Ditomopyge olsoni* are distinctly more primitive in both ceph-

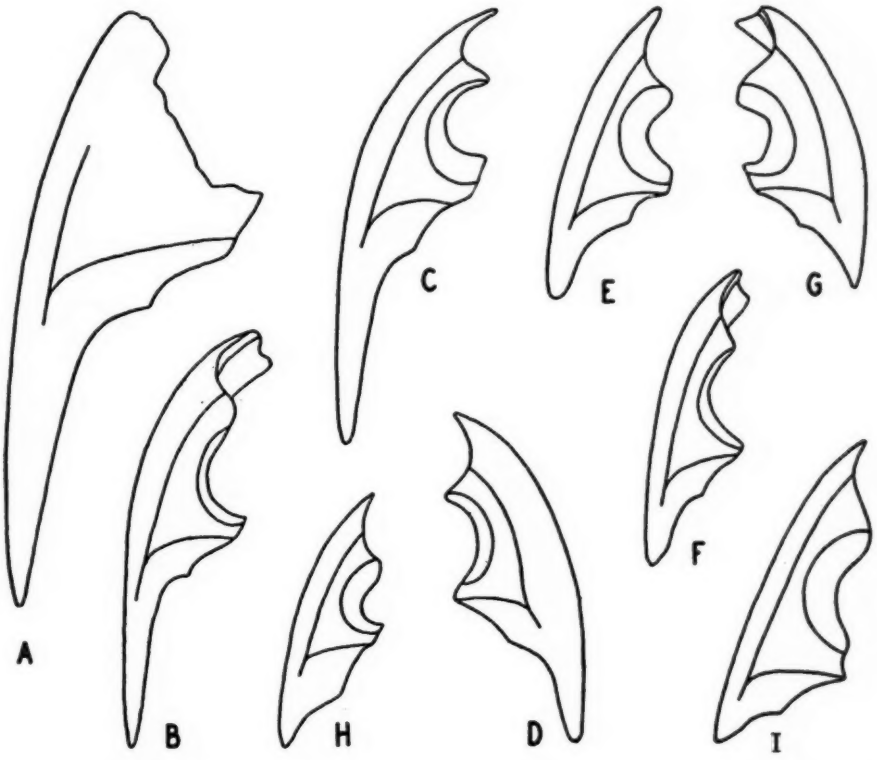

FIG. 4—Free cheeks of various species of *Ditomopyge* showing progressive decrease in length of genal spines. A, *D.* n. sp., Morrow; B, *D. olsoni*, lower Carbondale; C, *D. parvula*, upper Carbondale and lower McLeansboro; D, *D. scitula*, McLeansboro; E, *D.* n. sp., upper McLeansboro; F, *D. lansingensis*, syntype, Lansing formation, Kansas; G, *D.* n. sp., upper McLeansboro; H. *D*, n. sp., LaSalle limestone; I, *D.* n. sp., Florena shale, Lower Permian, Kansas. Unless otherwise specified, species are known in Illinois. The lower, middle, and upper McLeansboro are separated by the Shoal Creek and LaSalle limestones.

alon and pygidium than are mature individuals.

GENAL SPINES

Although no progressive changes of the genal spines have been noted among the Carboniferous trilobites as a whole, the series of species which makes up the genus *Ditomopyge* are characterized by a decrease in the length of these spines from lower to higher horizons, as shown in Figure 4. The contrast between the earlier and later members of this series is striking, and there is a general gradation connecting them, although this is not entirely regular, probably because of the varying stratigraphic ranges of different species. It is certain, however, that the species with short genal spines are more advanced in the evolutionary line of this genus, not only as indicated by their higher stratigraphic position, but also because the proportionate lengths of the genal spines decrease with progressive growth of the individual, as studies of *D. olsoni* and *D. lansingensis* have demonstrated (Weller 1935).

Specimens sufficiently abundant and from a sufficient number of carefully determined horizons to form the basis for such conclusions have been available to me only in the Pennsylvanian genera *Ditomopyge* and *Ameura*. Evolution in these two genera proceeded in quite different directions, however, and the genal spines of *Ameura* do not become shorter in later species.

CONCLUSIONS

The evolutionary changes that occurred during the development of the Proetidae in Carboniferous time are of three types. First, there are those which seem to have occurred at some definite time and were probably involved in the differentiation of the principal branches of this family, such as the appearance of a well marked pygidial flange and large eyes. Second, there are the changes which occurred at more or less different times in different lines, such as loss of the flat marginal border anterior to the glabella, and development of preoccipital lobe. Lastly, there are changes which are conspicuous and progressive only with a single genus, such as decrease in length of genal spines in *Ditomopyge*. All of these, together with others which are not known to be of evolutionary significance, are of great importance in the development of a genetic classification of the Carboniferous trilobites and the differentiation of species.

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J. MARVIN WELLER, ILLINOIS STATE GEOLOGICAL SURVEY, URBANA. MANUSCRIPT RECEIVED BY THE EDITOR, FEB. 2, 1937. PUBLISHED BY PERMISSION OF THE CHIEF, ILLINOIS STATE GEOLOGICAL SURVEY.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 4, PP. 347–354, 3 TEXT FIGS., JUNE, 1937

FORAMINIFERAL ZONATION OF CERTAIN UPPER CRETACEOUS CLAYS OF TEXAS

CLAUDE C. ALBRITTON, JR. and
FRED B. PHLEGER, JR.

ABSTRACT

It is demonstrated that close zonation can be accomplished in the Upper Cretaceous of Texas by means of Foraminifera alone. A fairly complete list of the occurrence of species at four localities is given. Two new species are described.

In the summer of 1935, at the suggestion of Dr. Joseph A. Cushman, numerous samples of richly foraminiferal clay and marl were collected at four localities in the Upper Cretaceous of Texas. These were taken from fresh cuts at 5-foot intervals throughout the entire thickness of the sections locally exposed. Subsequently the samples have been studied primarily to determine the degree of closeness to which the richly fossiliferous Gulf series may be zoned by Foraminifera alone.

Each species represented has been carefully identified by comparison with type figures and specimens in the library and collections of the Cushman Laboratory for Foraminiferal Research. The species cited probably represent an almost complete list of the forms to be found at the four localities, and the distribution chart should be of aid to collectors and students of Foraminifera.

We wish to express appreciation to Doctor Cushman for his generous supervision of this research. The collections studied have been deposited at the Cushman Laboratory.

LOCALITIES

The localities from which the samples studied in preparation of this paper were obtained are indicated in the following list. The rocks represented in these exposures are described by Adkins (see Sellards, Adkins and Plummer, Univ. Texas Bull. 3232, pp. 455–480, 495, 496, 1932).

Loc. 1.—Clay pit of the Corsicana Brick and Lumber Company, Corsicana, Navarro County, Texas. Corsicana chalky marl member of the Kemp formation, Navarro group.

Loc. 2.—Clay pit of the Whitselle Brick and Lumber Company, Corsicana, Navarro County, Texas. Corsicana chalky marl member of the Kemp formation, Navarro group.

Loc. 3.—Clay pit west of Southern Pacific Railroad, Palmer, Texas. Taylor group.

Loc. 4.—Clay pit east of the Southern Pacific Railroad, Ferris, Texas. Taylor group.

DISCUSSION ON ZONATION

In all sections the sample with the lowest number was taken at the bottom of the section, and the succeeding samples were taken above it at stratigraphic intervals of 5 feet. It has been found that close zonation

Table Showing Foraminifera from Texas Clay Pits

SPECIES	Cor	Whitselle								Perris									Palmer								
	1	2	3	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Haplophragmoides coronata				c			ra																							
excavata	rr												rc		rcc				rr			rc	r		cr		rr			
glabra											a																			
Ammobaculites stephensoni													r									c		r						
Gaudryina rudita	aa			a			a		c																					
rugosa											c																			
Clavulina clavata													ca		src				rr			ccccccc							r	
insignis	r			r			rr																							
Dorothia bulletta	r			r					r		r																			
Spiroloculina simplex													ra									cr								
Spiroplectammina laiickeri																			r											
Robulus navarroensis	aar						aac		a		a																			
münsteri															rrcacc			rcr												
pseudomamilligerus	rr			c			ccr		c																					
taylorensis													rc		ccaar			r												
Planularia disonna	ac			a			ccr		c																					
Dentalina annulata	r												r		r															
communis							r						r		r	r	r	cc				rc		rrrr						
gracilis	rar			c			ra		a		c																			
legumen	rr						r																							
soluta	r																													
pseudoscripta													cc		c	c		crr				ra		ccaa		a				
Nodosaria affinis													r	r																
alternata															r			r				r		r						
cf. obscura													r																	
prismatica									r		r											r								
Pseudoglandulina sp.	r																													
Saracenaria triangularis																			r											
Vaginulina multicostata	r								r																					
silicula	rr			c			a		c		r																			
simondsi									r																					
webbervillensis	r																													
Flabellina suturalis															r							r		c						
Frondicularia mucronata															r									r						
Kyphophyxa christneri									r				r		rrr			rc				c		cccar						
cushmani															r															
Lagena hispida									r																					
Nonionella robusta	r																													
Ecuvigerina americana	r												r									r								
gracilis															r			r												
Gümbelina globifera				r			r				r																			
globulosa													a	a	a	a	a	a	c	c	c	a	a	a	a	a	c	c	c	c
striata	r						r		r																					
tesseri													rr	r	c	c	c	rr	r	r	r						r			
Gümbelitria cretacea															r															
Ventilabrella carseyae	ccr			c			rr		c		r																			
eggeri									r				a	a	a	a	a	a	r	c	c	c	c	c	c	c	c	c	c	a
Bulimina quadrata	aa			a			cr		c		c																			
Neobulimina canadaensis																													r	
Bolivina incrassata var.lata													c		rrrr			rr				caar		r		r				
primitumida									r													r		crr		r				
cf. tenuis																			r					r		r		r		
watersi																														
Loxostoma cushmani		r											rc		aaaaaaa							crc		ccca					
plaita		r					r						r		rr			r						r		r	r			
Ellipsonodosaria granti											r																			
Discorbis correcta		cr							c															r						
Cyroidina depressa	ccr			c			cr		c		c				rr		r	c				rrc				r				
micheliana							c															r								
minuta													c		rr				r					r						
Globigerina belli																														
cretacea	rrr			a			cr		c		c		car		cr			r	r			cccc				rcrr				
Globigerinella aspera									r				r		rr			rrrr				rcr		rrcrr						
Orbulina universa																		r												
Globotruncana arca	acr			c			c		c		r		rc		rca			rrrr				rcccccaca								
canaliculata var. ventricosa																		cccc				rr								
fornicata													rc		rcacc			ccc				rcc		aacr					a	
Anomalina pseudopapillosa							r		r		r																			
Planulina taylorensis													rr																	

(For *Kyphophyxa* read *Kyphopyxa*, and for *Gümbelina tesseri* read G. *tessera*)

can be established with little difficulty, and that most of the samples can be distinguished by the association and abundance of the species contained in them. It is interesting to observe, however, that even at such highly fossiliferous localities as the Corsicana and Whitselle pits, barren zones do occur; each of these barren samples is composed almost entirely of selenite grains.

The samples from the Taylor beds (Ferris and Palmer pits) are easily recognized by the presence of *Clavulina clavata*, *Robulus taylorensis*, *Dentalina pseudoscripta*, *Gümbelina globulosa*, *Bolivina incrassata* var. *lata*, *Globotruncana fornicata*, and *Planulina taylorensis*. All these species are common to abundant in the Taylor samples and do not occur in the Navarro samples.

The following species are common to abundant in the Navarro samples and were not observed in the Taylor material: *Gaudryina rudita*, *Robulus navarroensis*, *Robulus pseudomamilligerus*, *Planularia dissona*, *Dentalina gracilis*, *Ventilabrella carseyae*, and *Bulimina quadrata*.

The samples at the various pits can be differentiated by certain species or associations of species. The distinguishing features of individual samples are summarized below, the relative stratigraphic position of the samples being indicated with the youngest at the top. For more complete information concerning occurrence, see the chart of species included in this paper.

Distinguishing Features of Samples

Loc. 1—Corsicana Clay Pit

Sample 3.—Occurrence of *Loxostoma cushmani* and *L. plaita* together with *Discorbis correcta*.

Sample 2.—Presence of *Clavulina insignis*, *Gümbelina striata*, *Vaginulina multicostata*, *V. webbervillensis*. Association of the two latter species with *Vaginulina silicula*.

Sample 1.—Presence of *Dentalina annulata*, *D. soluta*, *Nonionella robusta*, and *Eouvigerina americana*.

Loc. 2—Whitselle Clay Pit

Sample 0.—Abundance of *Haplophragmoides glabra*, *Gaudryina rugosa* and *Bolivina watersi* are common. *Ellipsonodosaria granti* is rare. All these species are restricted to this sample.

Sample 9.—Barren.

Sample 8.—This sample can be very easily distinguished by the presence of *Vaginulina multicostata*, *V. simondsi*, *Kyphopyxa christneri*, *Lagena hispida*, and *Discorbis correcta*.

Sample 7.—Barren.

Sample 6.—*Bolivina primitumida* and *Globigerinella aspera* occur with typical Navarro species.

Sample 5.—*Loxostoma plaita* and *Gyroidina micheliana* occur together with *Clavulina insignis*.

Sample 4.—*Dentalina communis*, *Clavulina insignis*, *Dentalina legumen*.

Sample 3.—Barren.

Sample 2.—Barren.

Sample 1.—*Dorothia bulletta*, together with *Haplophragmoides coronata* and *Clavulina insignis*.

Loc. 3—Palmer Clay Pit

Sample 9.—Complete absence of *Robulus taylorensis* and abundance of *Dentalina pseudoscripta*.

Sample 8.—Cannot be distinguished.

Sample 7.—Presence of *Neobulimina canadaensis*, *Gümbelina tesseri*, and *Globigerina belli*.

Sample 6.—Not easily distinguished.

Sample 5.—*Flabellina suturalis* and *Frondicularia mucronata*, with *Nodosaria alternata* and *Ammobaculites stephensoni*.

Sample 4.—Not easily distinguished from other samples.

Sample 3.—*Eouvigerina americana*, *Discorbis correcta*, and *Gyroidina minuta*.

Sample 2.—*Spiroloculina simplex*, with *Nodosaria prismatica* and *Flabellina suturalis*.

Sample 1.—*Gyroidina micheliana* and *Globotruncana canaliculata ventricosa*, with *Spiroloculina simplex*.

Loc. 4—Ferris Clay Pit

Sample 0.—*Saracenaria triangularis* and *Spiroplectammina lalickeri*.

Sample 9.—Bolivina cf. *tenuis* and *Globigerina belli*, with *Nodosaria alternata*.
Sample 8.—No distinguishing characteristics.
Sample 7.—Apparently not distinctive.
Sample 6.—Presence of *Orbulina universa*.
Sample 5.—Kyphopyxa cushmani, Gümbelitria cretacea, and *Globigerina belli*.
Sample 4.—Flabellina suturalis and *Frondicularia mucronata*, with *Dentalina annulata, Eouvigerina gracilis*, and *Globigerina belli*.
Sample 3.—The fauna is very meager and there appear to be no distinctive species.
Sample 2.—Ammobaculites stephensoni and *Nodosaria affinis* are rare, while *Spiroloculina simplex* is abundant.
Sample 1.—Nodosaria cf. *obscura* and *Eouvigerina americana*.

LIST OF SPECIES

The following annotated list of species gives references to readily available, authentic descriptions and figures of forms identified in this study and comments on occurrence in the strata examined.

Species of Foraminifera from Certain Upper Cretaceous Clays of Texas

Haplophragmoides coronata (H. B. Brady). (CUSHMAN AND JARVIS, *1928*, Cushman Lab. Foram. Research, Contr., vol. 4, pt. 4, p. 90, pl. 12, fig. 17.) Abundant to rare in the lower part of the Whitselle section.

Haplophragmoides excavata Cushman and Waters. (CUSHMAN AND WATERS, *1927*, Cushman Lab. Foram. Research, Contr., vol. 2, pt. 4, p. 82, pl. 10, figs. 3*a*, *b*.) Rare at the Corsicana clay pit; rare to common at the Ferris and Palmer clay pits.

Haplophragmoides glabra Cushman and Waters. (CUSHMAN AND WATERS, *1927*, Cushman Lab. Foram. Research, Contr., vol. 2, pt. 4, p. 83, pl. 10, figs. 6*a*, *b*.) Abundant at the extreme top of the section at the Whitselle clay pit.

Ammomarginulina stephensoni (Cushman). (CUSHMAN, *1933*, Cushman Lab. Foram. Research, Contr., vol. 9, pt. 3, p. 49, pl. 15, figs. 2*a*, *b*). "A distinctive species of rather wide distribution in the Taylor marl." Rare at the Ferris and Palmer localities.

Spiroplectammina lalickeri Albritton and Phleger, n.sp. (See p. 353, for description.) Rare in clay of the Taylor group at Ferris, Texas.

Gaudryina rudita Sandidge. (SANDIDGE, *1930*, Am. Midland Naturalist, vol. 13, pp. 342, 343, pl. 31, figs. 19, 20.) Fairly abundant at the Whitselle and Corsicana pits.

Gaudryina rugosa d'Orbigny. (D'ORBIGNY, *1840*, Soc. geol. France, Mem., vol. 4, p. 44, pl. 4, figs. 20, 21.) Present only at the top of the Whitselle section.

Clavulina clavata Cushman. (CUSHMAN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 589, pl. 17, fig. 4.) Occurs in the Cretaceous of Mexico. Rare to abundant throughout the Palmer and Ferris sections.

Clavulina insignis H. J. Plummer. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101 pp. 138, 139, pl. 8, figs. 1–4.) "An abundant form in the Navarro formation. It occurs also in the Taylor, where it is very common in places" (p. 139.) Rare at the Corsicana and Whitselle localities.

Dorothia bulletta (Carsey). (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3103, pp. 132, 133, pl. 8, figs. 13–17.) This species "in the Texas section is most common in the Navarro formation and occurs from base to top. In some places, notably in the pit of the Corsicana Brick Company, it is present in abundance. It occurs sparingly in the Taylor formation . . . and in the Austin chalk. . . . "

Spiroloculina simplex Grzybowski. (GRZYBOWSKI, *1901*, Wydz. mat-przyr, vol. 41, p. 45, pl. 7, fig. 21.) Occurs in the Cretaceous of Poland. Present at the base of the Ferris and Palmer sections.

Dentalina annulata (Reuss). (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 28, pl. 3, fig. 3.) "This is a widely distributed species in the Cretaceous of Europe and elsewhere. It is fairly common in the Cretaceous of Tennessee and other parts of the Gulf Coastal Plain." Rare at the Corsicana and Ferris clay pits.

Dentalina communis (d'Orbigny). (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, p. 149, pl. 11, fig. 4.) Cretaceous and Eocene in Texas. Rare at all the localities, except at the Corsicana clay pit where it was not observed.

Dentalina gracilis d'Orbigny. (D'ORBIGNY, *1840*, Soc. geol. France, Mem., p. 14, pl. 1, fig. 5.) Fairly common at the Whitselle and Corsicana localities.

Dentalina legumen (Reuss). (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 27, pl. 3, fig. 1.) "This common European Cretaceous species occurs in the Tennessee Cretaceous as well as in other parts of the Gulf Coastal Plain." Rare at the Corsicana and Whitselle sections.

Dentalina soluta Reuss. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 150, 151, pl. 11, fig. 14.) Observed only at the base of the Corsicana pit.

Dentalina sp. cf. *D. spinulosa* (Montagu). (SHERBORN AND CHAPMAN, *1886*, Royal Micr. Soc., Jour., ser. 2, vol. 6, p. 750, pl. 15, fig. 13.) Common to abundant at the Ferris and Palmer pits.

Cristellaria navarroensis H. J. Plummer. (PLUMMER, H. J., *1926*, Univ. Texas, Bull.

2644, pp. 39, 40, fig. 4.) Abundant at the localities which are of Navarro age.

Robulus münsteri (Reuss). (CUSHMAN, *1932*, Jour. Paleontology, vol. 6, p. 334, pl. 50, figs. 2*a*, *b*.) A common form of the Taylor marl provisionally referred by Cushman to the above species. Rare to abundant at the Ferris pit.

Cristellaria pseudomamilligerus H. J. Plummer. (PLUMMER, H. J., *1926*, Univ. Texas, Bull. 2644, pl. 7, figs. 11*a*, *b*.) Reported as somewhat rare in the Midway; no mention made by Plummer of the occurrence in Navarro beds. Rare to common at the Whitselle and Corsicana localities.

Astacolus taylorensis H. J. Plummer. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 143–145, pl. 11, fig. 16, pl. 15, figs. 8–11.) This species "is restricted to the Taylor formation in the outcropping Texas section, and is especially common in its upper half" (p. 144).

Astacolus dissonus H. J. Plummer. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 145, 146, pl. 11, figs. 17, 18, pl. 15, figs. 2–7.) " . . . in Texas outcrops is restricted to the Navarro formation, where it occurs from base to top and is comparatively rare." (p. 146)

Nodosaria affinis Reuss. (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 30, pl. 3, figs. 16–20.) Only rarely observed in the lower part of the Ferris section.

Nodosaria alternata Carsey. (CARSEY, *1926*, Univ. Texas, Bull. 2612, p. 35, pl. 4, fig. 7.) " . . . occurs only in the Taylor formation, in which it is rather scarce." Very rare at the Ferris and Palmer sections.

Nodosaria sp. cf. *N. obscura* Berthelin (not Reuss). (*Nodosaria obscura* BERTHELIN, *1880*, Soc. geol. France, Mem., ser. 3, vol. 1, p. 31, pl. 1.) Occurs in the Cretaceous (Albian) of France. Rare at the base of the section in the Ferris pit.

Nodosaria prismatica Reuss. (CHAPMAN, *1893*, Royal Micr. Soc., Jour., p. 594, pl. 9, fig. 21.) Occurs in the Gault of Folkestone. Rare at the top of the Whitselle section and at the base of the Ferris and Palmer sections.

Pseudoglandulina sp. H. J. Plummer. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, p. 508, pl. 10, figs. 16, 17.) "This form occurs very rarely in the Upper Cretaceous and Tertiary strata of the Gulf Coast of the United States."

Saracenaria triangularis (d'Orbigny). (CUSHMAN AND CHURCH, *1929*, Calif. Acad. Sci., Proc., ser. 4, vol. 18, p. 505, pl. 37, figs. 13, 14.) Occurs in the Upper Cretaceous of California. Observed only at the top of the section in the Ferris pit.

Vaginulina multicostata Cushman. (CUSHMAN, *1930*, Cushman Lab. Foram. Research, Contr., vol. 6, pt. 2, p. 28, pl. 4, fig. 4.) The holotype is from the Upper Cretaceous of Alabama. Very rare at the Navarro localities.

Hemicristellaria silicula H. J. Plummer. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, p. 148, pl. 10, figs. 8, 9.) " . . . restricted to the Navarro formation in Texas and is a very rare member of that fauna. . . . In the Corsicana clay pits it is very rare."

Vaginulina simondsi Carsey. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 161, 162, pl. 10, figs. 13–15.) " . . . occurs frequently in richly foraminiferal Navarro clay and is very rare in the underlying Taylor strata."

Vaginulina webbervillensis Carsey. (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 33, pl. 4, fig. 6; PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, p. 160.) Most abundant in the Navarro, although reported from the Eagle Ford.

Flabellina suturalis Cushman. (CUSHMAN, *1935*, Cushman Lab. Foram. Research, Contr., vol. 11, p. 86, pl. 13, figs. 9–18.) Reported from the Austin formation. Rare to common at the Taylor localities.

Frondicularia mucronata Reuss. (REUSS, *1845*, Die Verstein. böhm. Kreide, p. 31, pl. 13, figs. 43, 44.) A striking form which occurs rarely at the Ferris and Palmer localities.

Kyphopyxa christneri (Carsey). (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 168–171, pl. 12, figs. 9–19.) "In the Texas section *K. christneri* (Carsey) occurs in the upper Austin formation and in the lower Taylor, particularly below the zone of *Baculites taylorensis* Adkins, that lies about 150 feet above the compact Austin chalk in Travis County."

Kyphopyxa cushmani Albritton and Phleger, n. sp. (See p. 353 for description.) Rare in the Taylor group at Ferris, Texas.

Lagena hispida Reuss. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, p. 159, pl. 10, fig. 12.) "This minute and delicate test is rather rare in lower Navarro strata, and it occurs sparingly in both Lower and Upper Cretaceous formations in Texas."

Nonionella robusta H. J. Plummer. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 175, 176, pl. 14, fig. 12.) Observed only at the base of the Corsicana beds.

Eouvigerina americana Cushman. (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 45, pl. 7, figs. 11*a*, *b*.) "Very small specimens of this species are fairly common in some parts of the Selma chalk of Tennessee. They are smaller than the specimens of the same species in Texas."

Eouvigerina gracilis Cushman. (CUSHMAN, *1926*, Cushman Lab. Foram. Research, Contr., vol. 2, pt. 1, p. 5, pl. 1, figs. 2*a–c*.) Rare in the Ferris section.

Gümbelina globifera (Reuss). (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 176, 177, pl. 9, fig. 14.) Frequent in the Upper Cretaceous of Texas.

Gümbelina globulosa (Ehrenberg). (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 43, pl. 7, figs. 3–5.) Widely distributed in the Upper Cretaceous in mosts parts of the world. Very abundant at the Taylor localities. Not observed in the Navarro samples studied.

Gümbelina striata Cushman. (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 43, pl. 7, figs. 6, 7.) Rare in the Navarro samples.

Gümbelina tessera Ehrenberg. (CUSHMAN, *1932*, Jour. Paleontology, vol. 6, p. 338, pl. 51, figs. 4, 5.) A broad, compressed species, widely distributed in the Upper Cretaceous of the southeastern United States. Typical forms occur in the Taylor marl.

Gümbelitria cretacea Cushman. (CUSHMAN, *1933*, Cushman Lab. Foram. Research, Contr., vol. 9, p. 37.) Rare in the middle of the Ferris section.

Ventilabrella carseyae H. J. Plummer. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 178, 179, pl. 9, figs. 7–9.) " . . . very common in the Navarro formation and occurs also in the Taylor." This species was not observed in the samples taken from the Ferris and Palmer localities.

Ventilabrella eggeri Cushman. (CUSHMAN, *1928*, Cushman Lab. Foram. Research, Contr., vol. 4, p. 2.) Abundant throughout the sections which are of Taylor age.

Bulimina quadrata Cushman and Parker. (CUSHMAN AND PARKER, *1936*, Cushman Lab. Foram. Research, Contr., vol. 11, pt. 4, p. 100.) Abundant at the Corsicana and Whitselle sections.

Neobulimina canadaensis Cushman and Wickenden. (CUSHMAN *1931*, Tenn. Geol. Survey, Bull. 41, pl. 8, figs. 1*a–c*.) Observed in one sample near the top of the Palmer section.

Bolivina incrassata Reuss var. *lata* Egger, (EGGER, *1899*, K. bayer. Akad. Wiss., München, Abh., vol. 21, pt. 1, p. 46, pl. 16, figs. 8, 9.) Rare to abundant in most of the samples from the Ferris and Palmer sections.

Bolivina primitumida White. (WHITE, *1929*, Jour. Paleontology, vol. 3, p. 44, pl. 4, fig. 20.) Occurs in the Cretaceous of Mexico. Observed at the Whitselle and Palmer localities.

Bolivina sp. cf. *B. tenuis* Marsson. (*Bolivina tenuis* FRANK, *1925*, Greifswald Univ., Geol. palaeont. Inst., Abh., vol. 6, p. 20, pl. 2, fig. 9.)

Bolivina watersi Cushman. (CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 2, pt. 4, p. 88, pl. 12, fig. 6.) Observed only at the top of the Whitselle section, where it is fairly common.

Loxostoma cushmani Wickenden. (WICKENDEN, *1932*, Royal Soc. Canada, Trans., 3d. ser., vol. 26, sec. 4, p. 91, pl. 1, figs. 6*a*, *b*.) Occurs in the Upper Cretaceous of Canada. Abundant in all the Taylor samples observed, and also occurs at the top of the Corsicana section.

Loxostoma plaita (Carsey). (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, pp. 51, 52, pl. 8, fig. 9.) Widely distributed in the Upper Cretaceous of the Gulf Coastal Plain.

Dentalina granti (H. J. Plummer). (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 149, 150, pl. 11, figs. 8, 9.) Reported from Austin, Taylor, Navarro, and Midway in Texas.

Discorbis correcta Carsey. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 188, 189, pl. 14, figs. 1–4.) "This species has been observed in the Texas Upper Cretaceous most commonly in the Navarro strata. It is rare in the Taylor, and very rare in the Austin."

Gyroidina depressa (Alth). (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 190, 191, pl. 13, fig. 3.) "This species is common in the richly foraminiferal beds of Navarro age and is rare in the Taylor. It has been observed in the Cretaceous strata in California and in the Colon shale of Venezuela."

Gyroidina micheliniana (d'Orbigny). (CUSHMAN, *1932*, Jour. Paleontology, vol. 6, p. 342, pl. 51, figs. 12*a–c*.)

Gyroidina minuta White. (WHITE, *1928*, Jour. Paleontology, vol. 2, p. 294, pl. 38, fig. 12.) Occurs in the Upper Cretaceous of Mexico. Observed only in the Taylor samples.

Globigerina belli White. (WHITE, *1928*, Jour. Paleontology, vol. 2, p. 192, pl. 27, fig. 11.) Described by White from the Upper Cretaceous of Mexico. Observed only in the samples from the Taylor localities.

Globigerina cretacea d'Orbigny. (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 58, pl. 10, figs. 6, 7.) Common at all four localities.

Globigerinella aspera (Ehrenberg). (CUSHMAN, *1932*, Jour. Paleontology, vol. 6, p. 342, 343; *1931*, Tenn. Geol. Survey, Bull. 41, p. 59, pl. 11, figs. 5*a*, *b*.)

Orbulina universa d'Orbigny. (GALLOWAY AND MOREY, *1931*, Jour. Paleontology, vol. 5, p. 348, pl. 40, fig. 1.) Observed only in one sample from the middle of the Ferris section.

Globotruncana arca (Cushman). (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 59, pl. 11, figs. 6*a–c*.) "This is one of the most common and characteristic species of the Gulf series of the American Cretaceous."

Globotruncana canaliculata (Reuss) var. *ventricosa* White. (PLUMMER, H. J., *1931*, Univ.

Texas, Bull. 3101, p. 199, pl. 13, fig. 10.) Fairly common at the Taylor localities.

Globotruncana fornicata H. J. Plummer. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 198, 199, pl. 13, figs. 4–6.) Very common in nearly all the Ferris and Palmer samples.

Anomalina pseudopapillosa Carsey. (PLUMMER, H. J., *1931*, Univ. Texas, Bull. 3101, pp. 200, 201, pl. 14, fig. 13.) Observed only in the upper part of the Whitselle section.

Planulina taylorensis (Carsey). (CUSHMAN, *1931*, Tenn. Geol. Survey, Bull. 41, p. 62, pl. 12, figs. 5*a–c*.) Very abundant in all samples from the Ferris and Palmer sections.

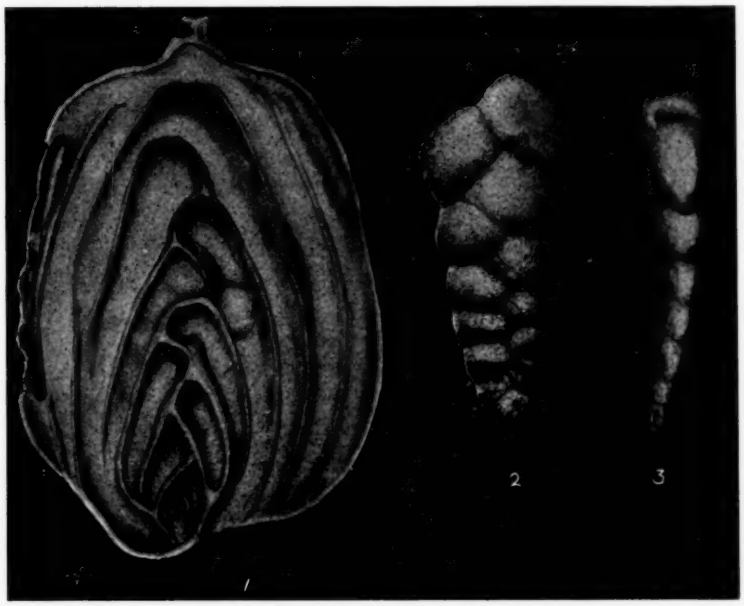


FIG. *1—Kyphopyxa cushmani* Albritton and Phleger, n. sp. Holotype, ×60. Taylor group, Ferris, Texas.
2, 3—Spiroplectammina lalickeri Albritton and Phleger, n. sp. Holotype, ×90. Taylor group, Ferris, Texas.

SYSTEMATIC DESCRIPTIONS

Family TEXTULARIIDAE Cushman

Subfamily SPIROPLECTAMMININAE Cushman

Genus SPIROPLECTAMMINA Cushman

SPIROPLECTAMMINA LALICKERI Albritton and Phleger, n. sp.
Text figures 2, 3

Test small, slender, elongate, slightly bent with sides converging toward an evenly rounded initial end; periphery narrowly rounded, initially smooth, lobulate in later portion of test; chambers numerous, first few in planispiral coil, succeeding ones biserial, increasing gradually in height as added; sutures fairly distinct, limbate, slightly raised in initial half of test, thereafter slightly depressed; sutures oblique, forming an angle of 20 to 45 degrees with the horizontal; wall arenaceous, smoothly finished, with a considerable amount of cement; aperture a low subrectangular opening at the flattened base of the last-formed chamber; color gray.

Remarks.—Spiroplectammina lalickeri is characterized by its elongate form, its evenly converging sides, and its low, subrectangular aperture. The only species with which it might be confused is *S. longa* Lalicker (Cushman Lab. Foram. Research, Contr., vol. 11, pt. 1, 1935,

pl. 1, figs. 4, 5), from the Lower Cretaceous of Texas. This latter species can be distinguished, however, by its subparallel sides and high, arched aperture.

Occurrence.—Rare in the clay of the Taylor group at Ferris, Texas. The holotype is Cushman Coll. no. 23330.

Family LAGENIDAE Cushman
Subfamily NODOSARIINAE Cushman

Genus KYPHOPYXA Cushman

KYPHOPYXA CUSHMANI Albritton and Phleger, n. sp.
Text figure 1

Test free, large, subquadrate or ovate in outline, thickest in central area, periphery truncate to slightly rounded; first few chambers planispirally coiled, succeeding five to seven chambers biserial and embracing, last few chambers frondicularian and curved downward around early portion of test; sutures of coiled and biserial portions marked by thin, continuous, plate-like elevations which are highest in the central area and but weakly developed in the frondicularian stage; walls smooth, thin, calcareous, finely perforate; aperture terminal, projecting, radiate.

Remarks.—*Kyphopyxa cushmani* is a comparatively rare form at Ferris, where it is associated with the common Taylor and Austin species, *K. christneri* (Carsey). *K. christneri* may be distinguished from the present species by the sharp convergence of its sides toward the aperture.

Occurrence.—Clay of the Taylor group, at Ferris, Texas. The holotype is Cushman Coll. no. 23331.

CLAUDE C. ALBRITTON, JR., SOUTHERN METHODIST UNIVERSITY, DALLAS, TEXAS. FRED B. PHLEGER, JR., 1234 N. GENEVA ST., GLENDALE, CALIFORNIA. MANUSCRIPT RECEIVED BY THE EDITOR, OCTOBER 5, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 4, PP. 355–366, PL. 44, JUNE, 1937

LARGE OYSTERS FROM THE GULF COAST TERTIARY

HENRY V. HOWE

ABSTRACT

Fossil oysters are useful to field geologists in the Gulf Coast, but paleontologic literature concerning them is confused. *Ostrea gigantissima* Finch, 1824, the first fossil described as coming from the Tertiary of North America, was found at Shell Bluff, Georgia, in beds correlated with the Jackson group, Eocene. This species, redescribed by Conrad from the same locality under the name *O. georgiana*, was used by Conrad as a guide fossil for his Shell Bluff group and his specific name has been in common use for a hundred years. Conrad and subsequent workers, however, confused this oyster with practically all other large oysters from the Tertiary of the Gulf Coast, and nearly all the references really apply to other species. Many other large fossil oysters have been described, and the synonymy is very confusing. A large oyster of the lower Miocene Chickasawhay member of the Catahoula formation, confused by DeGregorio with *O. georgiana*, is described in this paper under the name of *O. blanpiedi*, n. sp. A summary points out certain corrections to stratigraphical terminology of the Gulf Coast Tertiary.

Our knowledge of the Tertiary formations of the Atlantic and Gulf Coastal Plains begins with an essay by the English geologist John Finch (1824) which rudely shattered the idyllic concept of Maclure,—"father of American geology,"—Cleaveland, and others, who had shown the vast coastal region as alluvium on their geological maps. Finch, in a frankly preliminary outline, subdivided the sediments that make up this extensive terrain into seven divisions: (1) Ferruginous Sand, (2) Plastic Clay and Sand Formation, (3) Calcaire Silicieuse, of the Paris Basin, (4) London Clay, (5) Calcaire Ostrèe, (6) Upper Marine Formation, (7) Diluvial. He suggested their correlation with the Upper Cretaceous and Tertiary formations of Europe, and concluded:

> Geology will achieve a triumph in America when the term alluvial shall be banished from her Geological Essays, or confined to its legitimate domain, and then her tertiary formations will be seen to coincide with those of Europe, and the formations of London, Paris and the Isle of Wight, will find kindred associations in Virginia, the Carolinas, Georgia, the Floridas, and Louisiana.

Spurred by Finch's essay, an enthusiastic group of scientists associated with the then young Philadelphia Academy of Natural Sciences began energetic investigation of the Coastal Plain formations. Morton described numerous fossils from supposed Cretaceous outcrops assigning them to the "Ferruginous Sand." Conrad, Lea, Say, Vanuxem, and others wrote numerous articles describing the fossil content of Tertiary beds. Not only did most of Finch's formational names appear in this literature, but many new ones, and vigorous arguments developed regarding their relative positions in the column. Many of the absurdities were clarified by the visit of Sir Charles Lyell to this country in 1841–1842, but confusion still exists in regard to a number of the most famous old fossil localities.

In the Georgia-South Carolina

portion of the Coastal Plain the most visited, most described, and most misunderstood locality is probably Shell Bluff on the Savannah River, below Augusta. Published sections and descriptions of Shell Bluff (see Veatch and Stephenson, 1911; also Ruffin, 1843; Loughridge, 1884; Clark, 1891; Sloan, 1908; Brantly, 1916; Cooke and Shearer, 1918) differ materially in detail, because for a quarter of mile back from the river the bluff is a complex of horsts and grabens due to "land-slips," apparently formed as explained by Veatch (1902). This noted exposure derived its name from its abundance of the large fossil oysters that characterize the upper Eocene of South Carolina and eastern Georgia. Probably the first reference to these oyster beds was made by the English traveller William Bartram (1791). Mitchill (1818, p. 401) in describing the geology of South Carolina refers to a publication by Gov. John Drayton (1802; see Mitchill, 1818)

> for the distinct account he has given of the stratum of enormous oyster-shells, extending from Nelson's ferry on the Santee, southwest to the Three Runs on the Savannah river.

In discussing Georgia, Mitchill (1818, p. 402) likewise says of this oyster-bearing stratum:

> The shell banks, as they are termed, make their first appearance on the south bank of Savannah river, near the place called *White Bluff*, about a hundred miles on a straight line from the sea shore, and run about southwest. They are not one entire ridge, but the ground is higher for about six or eight miles in width than it is above or below. On this ridge the shells make their appearance, in many places near the surface, and in others deeper. Not only the *oyster-shell* is found, but *clam* shells and a scalloped shell nearly similar to the clam shell. Some of them are large, and appear to be entire; others are cemented together. I think that I have seen some of them large enough to contain the foot of a common man. I have seen the shells in different parts of the ridge, for the space of forty miles. They are made use of for lime, but are not supposed to afford a product so good as the common shell lime.

It is thus seen that the oyster bed which formed the basis for Finch's *Calcaire Ostrèe* was already established in literature. Finch had reason to assume that readers would know the oyster bed to which he referred, and there can be no doubt from their publications that both Vanuxem and Conrad understood precisely the large oyster which he described. Finch (1818, p. 41) states that the *Calcaire Ostrèe*

> commences at the Eutaw springs near Santee river in South Carolina, passes to Orangeburgh, and crosses the Savannah river fifteen miles below Augusta, occasionally disappearing under the sand,

which indicates clearly that this is the oyster bed referred to by earlier writers. Attempting to indicate the westward extent of the oyster bed, Finch writes:

> It may then be traced to Burke County in Georgia, crosses the Ogeechee near Louisville; then near Sandersville, passing through Wilkinson County.

The remainder of the description refers to a locality in Florida, and with obvious error to Cretaceous outcrops in Alabama. The quoted description, however, is remarkably accurate, for if one traces the points mentioned, he finds that Finch has delineated almost precisely the outcrop of beds now termed Jackson Eocene as shown on the new geological map of the United States (U. S. Geol. Survey, 1932). If Finch erred

in part of his description of the extent of the formation, which he notes is based on observations of Maj. N. A. Ware, Conrad and his followers could not criticize unduly, for, in confusing the large oyster of Shell Bluff with numerous other large oysters, they correlated beds ranging in age from Claiborne Eocene to middle Miocene, and many of them even referred the oysters to the Recent species *O. virginica*.

In defining the *Calcaire Ostrèe*, Finch stated:

> This extensive formation is chiefly composed of a large species of ostrea, which I believe has not yet been described. A specimen of it may be seen in the Philadelphia museum; it is twelve inches long and two and three-quarters wide, and each valve from half to two and a quarter inches thick—Major Ware says they occur larger; on account of their great size I propose to call them Ostrea Gigantissima. The shells appear but slightly changed by their residence in the earth, and are in many parts used for burning into lime.

Despite the remarks of Conrad, Harris, and others that *Ostrea gigantissima* was not described, the above is fully as complete and accurate a description as Conrad (1834) gave for the same species when he redescribed it ten years later from the same general localities under the name *Ostrea georgiana*.

Vanuxem (1829), whom Finch (1818, p. 36) specifically mentioned as a source of information for his essay, published numerous observations which could only have been obtained from Finch but does not mention his name. Vanuxem uses "Beds of Ostreae" in place of "*Calcaire Ostrèe*," and in discussing the oyster beds, states:

> The highest point to which this deposition rises is about two hundred and fifty feet, which is near the line of junction with the primitive. The highest known bluff containing shells, is *Shell Bluff*, on Savannah river: it is about seventy feet high, formed of various beds of impure carbonate of lime, of comminuted shells, and having at its upper part, the *ostrea gigantea?* in a bed nearly six feet in thickness (represented in the diagram by the dotted line section of No. 3). It has been mentioned by those persons who have written on this subject, that a continuous bed of these ostrea commences at Eutaw Springs, and passes through Georgia, the Floridas, Alabama, &c. It is well known that these oyster shells are found abundantly in certain places in the states just mentioned; not, however, as a continuous mass, but in beds, or partial depositions, similar to those which now exist in our bays and estuaries. In all places where met with, these ostreae occupy the upper part of the Tertiary deposit.

While Vanuxem's observation that the oysters do not occur in a continuous mass is correct and original, the inclusion of Florida and Alabama in describing the extent of the oyster beds shows that he derived his information concerning distribution from Finch, as others had traced these beds only from the vicinity of Eutaw Springs to a point about 40 miles southwest of Shell Bluff in Georgia. The name "*ostrea gigantea?*" seems obviously to be a corruption of Finch's *Ostrea gigantissima*, and may conceivably be explained by a footnote (Vanuxem, 1829, p. 59).

> The friends of Mr. Vanuxem are aware that he lately passed a few days in this city, prior to his embarkation for Mexico: during that period, his time was so engrossed with preparatory arrangements, and with the publication of a chemical essay, that he requested me to arrange the materials of the following paper. After I had finished the manuscript we examined it together, and it is now published as corrected by the author. ——S. G. M(orton).

It is possible that Vanuxem, who had just made a failure of the first

South Carolina Geological Survey (Merrill, 1924, p. 101), in his hurry misspelled this fossil name and overlooked a question mark perhaps inserted in the manuscript by Doctor Morton.

In contrast with Vanuxem's failure to give credit to Finch, Conrad (1835) attempted to discredit him. He writes:

> In a preceding No. of this work, (page 28) I alluded to a deposit of large oyster shells in South Carolina and Georgia, which Mr. Finch has termed *Calcaire Ostree*, believing that it constituted a distinct formation, not referriable (sic.) to any particular period in the scale of European deposits. I have since visited a portion of the southern states, and can say, from personal observation, that the continuous bed of oyster shells described by travellers and others, includes, in fact, two distinct formations, one of secondary, the other of tertiary origin, and that *two distinct species of Ostrea have been confounded with that "finger post" of the cretaceous strata, Exogyra costata*, Say. These three shells combined constitute that anomalous species called *Ostrea gigantissima* by Mr Finch. Upon this supposed species was erected the formation termed *Calcaire Ostree*, which we have proved to be no more than the creation of Mr Finch's imagination; yet a traveller ignorant of the generic or specific character of the shells alluded to, would be likely to arrive at the same conclusion with that geologist and suppose that a continuous deposit, characterized by a single species of *Ostrea*, extended from South Carolina to the Mississippi river. Of the two species of *Ostrea* mentioned above, the *O. sellaeformis* characterizes a peculiar stratum of the *Eocene* at Claiborne, and is also found in the newer cretaceous strata of South Carolina. The *O. Georgiana*, (nobis) which much resembles *O. longirostris*, Lam. is characteristic of the *Eocene* strata at Shell Bluff on the Savannah river; near Milledgeville, Georgia, and at Orangeburgh, South Carolina.

Following is Conrad's (1834) original (unillustrated) description of *Ostrea georgiana*.

> Shell thick, elongated, straight; hinge much produced; upper valve nearly flat. Localities: Orangeburgh, S. C., Shell Bluff and near Milledgeville, Ga. This species is found 22 inches in length and is remarkable for the length and depth of the cardinal fosset.

One may admire a fighter, but it appears that Conrad took unfair advantage of Finch in the remarks quoted, a circumstance apparently caused by his own misunderstanding of the age of many of the outcrops mentioned. (1) A comparison of Finch's description with Conrad's shows that they were describing the same species, the former's description being the more accurate because of the detailed measurements given. I doubt if anyone can produce specimens of either *Exogyra costata* or *Ostrea sellaeformis* which have dimensions even remotely approaching those given by Finch for *O. gigantissima*. Thus, Conrad could not fairly state that Finch had confused *O. gigantissima* with either *E. costata* or *O. sellaeformis*. (2) Conrad, in giving the range of his species *O. sellaeformis* as Claiborne and also "newer" Cretaceous of South Carolina, confused the column as badly as did Finch, for, as was pointed out by Lyell (1845) the "newer" Cretaceous of Conrad, Morton, and others was really upper Eocene. The extent of Conrad's confusion is illustrated by his geological map of Alabama which accompanied his report, for this map shows Claiborne Bluff as an isolated island of Eocene in a Cretaceous sea, and, in general, the Tertiary formations older than Jackson Eocene are shown as "Greensand," whereas those from Jackson to Citronelle Pliocene are indicated as "newer Cretaceous." (3) Conrad's localities, while agreeing in general with Finch's and including Shell Bluff, were hardly as

accurate. The locality given as "near Milledgeville" probably refers to a place 10 miles or more east of the city, for in paleontologic literature the term "near" was, and by certain persons still is, considered sufficiently definite designation of a locality if it is within 10 miles of the place mentioned. Milledgeville is shown on the new U. S. Geological Survey map to be located on Carboniferous granites! (4) Conrad expressed disbelief that a formation characterized by a particular species of fossil oyster could extend from South Carolina to the Mississippi River. Yet, after he had described the fauna at Vicksburg (Conrad, 1846–1847) and had named the Jackson group and described its fossils (Conrad, 1855), he made the same assertion in regard to his *O. georgiana*, and used this species as the basis for definition of the stratigraphic unit which he termed the "Shell Bluff Group" (Conrad, 1866). At this time he claimed that the large Shell Bluff oyster occurred in the middle of the section at Vicksburg, Miss., occupying a position below limestone which he considered to be Jackson Eocene in age, but which Cooke (1923) and Morse (1935) have rightly or wrongly (see Mornhinveg and Garrett, 1935) assigned to the Glendon limestone. It appears that in describing the Shell Bluff group, Conrad, whose memory was notoriously unreliable (see Merrill, 1924, p. 201), had forgotten his previous publications dealing with the formations exposed at Jackson and Vicksburg, Miss. This confusion of upper Eocene and Oligocene formations in Conrad's definition of the Shell Bluff group was immediately pointed out by Hilgard (1866).

I have visited the Oligocene outcrops at Vicksburg many times in the past fourteen years but have never observed any large oyster there that might reasonably be confused with *O. gigantissima* as described by Finch (see Note 1, p. 365), or with types of *O. georgiana* Conrad. Despite the fact that Hilgard had pointed out the inappropriateness of the Shell Bluff group, the reputation of Conrad had become such that this name continued in sporadic use by other geologists (see Dall and Harris, 1892; Dall, 1898; Vaughan, 1900), each time in a different sense from that intended by its author. Likewise the mere suggestion that Conrad's *O. georgiana* could be used as a guide fossil in the Gulf Coast almost immediately resulted in a search for large oysters. The name *O. georgiana* has appeared in geological publications with ever growing frequency, but in very few cases have the oysters referred to had any real resemblance, other than in size, to the large Shell Bluff species.

To Dall (1898*a*, p. 683; 1909) probably belongs the doubtful distinction of having combined the greatest variety of fossil oysters under the name *O. georgiana*. In uniting with it the large species, *O. titan*, which Conrad (1854, 1857) described from the Miocene (see Note 2, p. 365) of San Luis Obispo, Calif., and another large species, *O. con-*

tracta, which Conrad (1857*a*) described from "Oyster Point, Mexico" (see Note 3, p. 365), he was apparently guided primarily by size. This, however, could not have been the criterion used by him in adding *O. mauricensis* Gabb (1860) to the list of species which he considered the same as *O. georgiana*, for Gardner (1926) has pointed out that Gabb's type was a frail little shell only 1½ inches in length, described from Cumberland County, New Jersey. Nor could shape have been the only criterion, when to the list he added *O. bourgeoisii* Rémond (Rémond, 1863; Gabb, 1869, p. 33, pl. 11, fig. 57), a species with a very narrow ligamental pit, described from the upper Miocene (see Note 4, p. 366) of Kirker Pass, Calif., and *O. tayloriana* Gabb (1869, p. 34, pl. 12, fig. 60), another California species, which, from its picture, is almost as wide as long.

The confusion is very great at this point, and much of it can be traced to a discussion by Dall (1898*a*, pp. 675–678) on the "Origin of the Mutations of Ostrea." In this he pointed out that oysters which lie on a muddy bottom are less commonly ribbed than those which grow in a more exposed environment, and that those which live in areas where currents are strong are more likely to be elongate than those which grow in still water. Consideration of these environmental factors was probably responsible for Dall's combining so many oysters of different shape from widely separated areas, and his impression of the influence of human consumption upon the average size attained by the Recent species *O. virginica* (see Dall, 1898*a*, p. 676) caused him to conclude that the common medium-sized oyster of the lower and middle Miocene of Florida represented the "young" or "normal form" of the gigantic upper Eocene Shell Bluff species. Under the name *Ostrea georgiana*, to which he appended the descriptive phrase "forma normalis," Dall (1898*a*, p. 684) states:

> The young *O. georgiana* is the characteristic fossil of the Upper Oligocene of the Gulf States often found in northern Florida scattered over the surface of the Vicksburg limestone from which the Upper Oligocene marl has been dissolved away. It is the "leit fossil" of the Grand Gulf beds, though not confined to them, and occurs in the single meagerly fossiliferous bed below the Altamaha grits . . .

He then gave a long list of localities in Florida, most of which are now referred either to the "Hawthorn formation" or to the Oak Grove (middle Miocene).

More recently Gardner (1926), in her comprehensive report on the molluscan fauna of the Alum Bluff group of Florida, recognized that the Miocene species of oyster was distinct, and described it as *O. normalis*, attributing the authorship to Dall, because of his descriptive phrase.

Probably the most peculiar treatment accorded the long-suffering Shell Bluff oyster was that of Harris (1919) when he placed *O. gigantissima* Finch (stating that it was undescribed!) and *O. georgiana* Conrad, together with six other described species, in the synonymy of the

tiny, nearly circular *O. alabamiensis* Lea (1833). Harris begins a lengthy discussion of *O. alabamiensis* with the statement:

> The most remarkable character of this species is the fine divaricate sculpturing of the corneous epidermis,

a feature not mentioned by Lea, nor shown in his figure. In tabulating his synonymy, Harris apparently discarded all considerations of size, shape, hingement, and other features, in favor of the epidermis, a portion of the shell seldom well preserved in fossil oysters. He was not the first paleontologist, however, to ascribe such an epidermis to the large Shell Bluff species. Dall (1903), five years after confusing the Eocene Shell Bluff oyster with the middle Miocene species from Florida, states:

> In this connection it may be observed that the collection of typical specimens of *Ostrea georgiana* Conrad shows that this species, to which large oysters from all parts of the Tertiary have been hastily referred by some authors, is well distinguished when in perfect condition by its surface sculpture. This is characterized by low, flattish, distally formed radial riblets, quite different from anything observable on the surface of *O. mauricensis* or *O. virginica*, which occupy a similar niche in the faunas succeeding the Eocene. As in all oysters, this thin sculptured layer is easily decorticated, and to this fact is largely due the confusion which has existed on the question of the geological range of this species.

When I visited Shell Bluff there were many hundred specimens of the large oyster exposed in the banks of the Savannah River, but after searching for the better part of a day, I was able to locate only one specimen which showed an indication of radiating riblets. Since Dall considered the Florida Miocene shell the "normal form," it may well be that his discussion really refers to the latter species.

Once an idea has been published, it tends to be perpetuated. Thus Gardner (1923) accepted Harris's placement of *O. georgiana*, though she varied it somewhat by making it a subspecies of *O. alabamiensis*. In doing so she followed Dall in placing the California Miocene species *O. titan* in the synonymy and gave it a range through the Cook Mountain, Yegua, Fayette, and Frio formations, listing a large number of localities. She noted that it differed in size, shape, surficial ornamentation, and hinge structure in the different horizons, but stated:

> Only a very small percentage of individuals retain the fine epidermal sculpture, the one constant feature, and one identical with that of *O. alabamiensis*.

Kellum (1926), using Gardner's designation, *Ostrea alabamiensis* subsp. *georgiana* Conrad, copied her synonymy (including *O. titan*) but did not indicate where this name originated, and, in describing the paleontology of the Castle Hayne marl, said:

> *O. georgiana* is very abundant at one locality in North Carolina. At Polloksville, on Trent River in Jones County, it forms a bed 15 feet thick. For the most part the shells are large and thick, but they are so weathered that it is difficult to procure a complete specimen. Young individuals retain perfectly the fine epidermal radial sculpture, which, according to Miss Gardner, is the one constant feature of *O. georgiana* and one identical with that of *O. alabamensis* [*sic*].

From these later publications it might readily be deduced that the only satisfactory manner of determining large fossil oysters is by examining the young partially-de-

veloped shells! This is a conclusion strikingly at variance with that reached by workers on ammonites and nearly all other forms of life, and should not be taken too seriously, for as Gardner (1926) has aptly said, "it is difficult to prove anything by a young oyster."

In view of what has happened to *O. gigantissima* since it was first described, I feel extremely hesitant to describe another species of large oyster. I do so solely because B. W. Blanpied and other members of the Shreveport Geological Society have found it very useful in mapping the outcrop of the Upper Chickasawhay member (see Note 5, p. 366) of the Miocene Catahoula formation. Experience of only eighteen years in paleontology perhaps hardly qualifies one to state whether all large oysters should be considered as the same species, or, if not, just what limits should be placed upon them, especially since distinguished earlier writers have differed so markedly in their interpretations. Paleontologists of the Pacific Coast have not followed the example of workers in the Gulf Coast in combining all of their large oysters with the one described from Shell Bluff. It seems pertinent to remark, also, that generic names, whether of oysters or Foraminifera, should not be used in designating either formations or zones (see Note 6, p. 366).

I suggest also that paleontologic literature will be benefited by banishment of the term "near" as applied to descriptions of fossil localities, or, at any rate, by confining it to proper use.

DESCRIPTION OF SPECIES

Genus OSTREA Linnaeus

OSTREA GIGANTISSIMA Finch

Plate 44, figures 5, 6

Ostrea gigantissima FINCH, *1824*, Am. Jour. Sci., vol. 7, p. 40.

Ostrea georgiana CONRAD, *1834*, Acad. Nat. Sci. Philadelphia, vol. 7, p. 156.

This species, abundant in the upper Eocene at Shell Bluff, Georgia, is remarkable for the regularity of its latitude and thickness. Finch stated that the specimen he described was 12 inches long, 2¾ inches wide and each valve was from one-half inch to 2¼ inches thick. These dimensions give an excellent impression of the size and shape of the average specimen. After examining a large number of specimens, I found that, while the greatest length (altitude) may even exceed 20 inches, the width (latitude) is usually between 2½ inches and 4¼ inches, and the thickness of both valves seldom exceeds 3 inches. While the beaks are usually curved, the remainder of the shell is nearly always elongated in a straight line. The upper valve is thinner than the lower. In most cases both valves are devoid of ornamentation other than growth laminae. The ligamental area is high and broad; strongly depressed in the lower valve, elevated in the upper valve. The muscle scars are large, ovate near the margin, and rather indistinct.

Dimensions of figured specimen: height, 12 inches; width, 3½ inches; thickness, 3 inches near the beaks, 1¼ inches near the middle. Dimensions of ligamental area: height, 3½ inches; width, 2¼ inches. Dimensions of muscle scar in upper valve; height, 2 inches; width, 1½ inches.

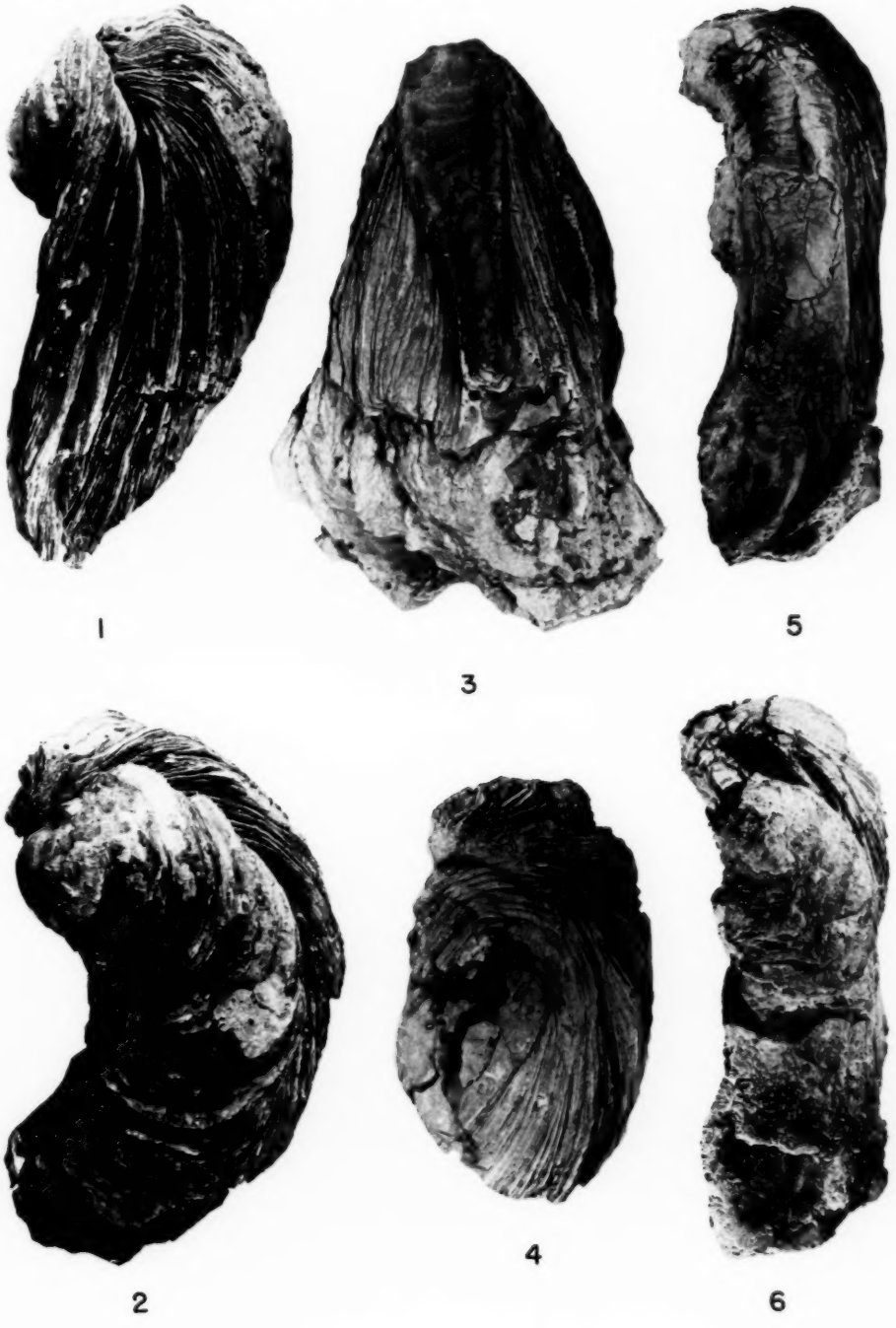
Occurrence.—Shell Bluff, Ga.

Types.—Neotype deposited in Acad. Nat. Sci. Philadelphia Mus., July 10, 1935; homoeotype, Louisiana State Univ., Geol. Mus. 237.

OSTREA BLANPIEDI Howe, n. sp.

Plate 44, figures 1–4

Ostrea gigantea JOHNSON, L. C., *1889*, Am. Jour. Sci., 3d ser., vol. 38, p. 215, Chicka-



1 3 5

2 4 6

Howe, Tertiary Oysters

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sawhay River, Wayne County, Mississippi (not *O. gigantea* Vanuxem, 1829). —, *1934*, Shreveport Geol. Soc., Guidebook Eleventh Annual Field Trip, unnamed figure on cover.

Ostrea georgiana De Gregorio, *1890*, Annales de Géologie et de Paleontologie, Livoraison 8, p. 177 (in part-reference to Choctaw Bluff, Ala.).—Smith, E. A., *1894*, Alabama Geol. Survey, p. 114, Choctaw Bluff (not *O. georgiana* Conrad, 1834).

Shell very large, massive, elongate, usually somewhat curved. The lower valve is usually rounded, the upper valve flattened; both valves crossed by widely spaced incremental lines. Ligamental area comparatively narrow, elongate, and flattened; faintly depressed near the margins and elevated along the longitudinal axis in the upper valve; elevated near the margins and depressed along the longitudinal axis in the lower valve.

Dimensions of holotype: height, 12 inches; width, 6 inches; thickness, 5 inches. Dimensions of ligamental area: height, 3 inches; width, 1½ inches.

Remarks.—This species, named in honor of B. W. Blanpied who has done so much field work on the Tertiary formations of the Gulf Coastal area, is much more massive than *O. gigantissima* Finch and is composed of many more incremental layers. The dorsal valve sometimes retains remnants of the epidermal covering which exhibits fine radiating, forked riblets, a feature probably possessed by many large species of *Ostrea*. The type specimen is only a moderate-sized individual. It was obtained from a small stream gully one-eighth of a mile northwest of the type locality of the Upper Chickasawhay member of the lower Miocene Catahoula formation in the NW. ¼ sec. 10, T. 8 N., R. 7 W., Wayne County, Miss. At the type locality of the Upper Chickasawhay, specimens that attained a length of fully 2 feet were present near the top of the bluff, but were too badly leached to permit removal. The ligamental area of one of these is illustrated (pl. 44, fig. 3). The flattened portion where the ligament was attached has a height of 6¾ inches and a width of 2 inches near the beaks, but tapers to 1 inch near the opposite end. This very narrow ligamental area on such a large oyster is markedly different from that possessed by the Jackson Eocene *O. gigantissima* Finch, or *O. titan* Conrad, the gigantic oyster of the California Miocene.

Occurrence.—Mr. Blanpied (Shreveport Geol. Soc., 1934) has found *O. blanpiedi* to occur in Upper Chickasawhay sediments as far west as Leaf River, Miss., at a locality 3.5 miles south of Sylverina, Smith County, in sec. 33, T. 2 N., R. 9 E., in a small creek below Keys Mill Pond. He has likewise traced these large oysters as far east as Choctaw Bluff, Alabama River, sec. 27, T. 5 N., R. 3 E., Ala.

Types.—Holotype, Louisiana State Univ., Geol. Mus. 238; paratype, 239.

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Explanation of Plate 44

Figs. *1–4*—*Ostrea blanpiedi* Howe, n. sp. *1*, Edge view, ×¼, of holotype, Louisiana State Univ., Geol. Mus., 238. *2*, Lateral view, ×¼, of holotype, Louisiana State Univ., Geol. Mus., 238. *3*, Ligamental area of upper valve of very large specimen, ×¼, paratype, Louisiana State Univ., Geol. Mus., 239. *4*, Ligamental area of lower valve. Figured specimens from sec. 10, T. 8 N., R. 7 W., Wayne County, Miss. (p. 362)

5, 6—*Ostrea gigantissima* Finch. *5*, Interior view of lower valve, showing ligamental area, ×¼, homoeotype, Louisiana State Univ., Geol. Mus., 237. *6*, Same specimen with upper valve in place, Shell Bluff, Ga. (p. 362)

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NOTE 1.—As Finch stated in his description that the specimen which he described was in "the Philadelphia museum," I asked my colleague, Dr. Richard J. Russell, to visit the museum of the Philadelphia Academy during the winter of 1934–1935 to attempt to ascertain its whereabouts. Under date of Feb. 20, 1935, I received the following letter from Dr. Henry A. Pilsbry, Curator.

I have had a thorough search made for the type of *Ostrea gigantissima* Finch, but without result. Finch says that he placed it in the "Philadelphia Museum" another name for Peale's Museum. This was burned, with nearly all of the contents. I have had occasion to look up some of Peale's collections in Florida and Columbia, but with the exception of one shell, which we have, the specimens seem to have perished.

I think that the dimensions given by Finch for his type are sufficient to reclaim his name for the species. He also mentioned the most famous locality, on the Savannah River, 15 miles below Augusta.

O. gigantea was mentioned by Morton and Vanuxem in Jour. Acad. N. S. Phila. VI, 69, from the same shell bluff, but without a word of description, therefore of no standing in nomenclature.

Morton's paragraph was quoted by Conrad in J. A. N. S. VII, 1834, p. 118. *O. gigantea* was mentioned later by A. Heilprin, Jour. Acad. Nat. Sci. 2d Series, Vol. IX, p. 149, as equivalent to *O. georgiana* Conr.

Dr. Francis Harper, of the "Biological Abstracts" staff here, informs me that in John Bartram's *unpublished* Journal, 1765, he describes this big oyster from the Savannah River bluff. He was no doubt the first civilized man to notice it.

Finding that Finch's original specimen is apparently lost, I made a trip to Shell Bluff, Georgia, the following month. There I found that numerous specimens could be obtained which precisely fitted the dimensions given by Finch for *O. gigantissima*. I collected several and deposited one at the museum of the Philadelphia Academy to replace Finch's lost type. The remainder are deposited in the museum of the School of Geology, Louisiana State University, Baton Rouge, Louisiana.

While visiting the Philadelphia Academy, I was assisted by Dr. E. G. Vannatta, who located for me Conrad's types of *O. georgiana*. Conrad's specimens are slightly larger than the one described by Finch, but possess the same relative dimensions and are undoubtedly the same species.

NOTE 2.—*Ostrea titan* is considered by B. L. Clark (*Calif. Univ., Dept. Geol. Sci., Pub.*, vol. 8, no. 22, p. 447, 1915) to have a range from lower Monterey (middle Miocene) to Santa Margarita (upper Miocene). Dall reports a specimen from "Miocene of Coos Bay, Oregon," which probably refers to the Empire formation, which I (H. V. Howe, *Calif. Univ., Dept. Geol. Sci., Pub.*, vol. 14, no. 3, pp. 85–114, 1922) have showed to be Pliocene in age.

NOTE 3.—I have not been able to locate, in the publications of later writers dealing

with the Rio Grande region, any mention of the exact location of "Oyster Point," and therefore cannot state the age of the beds from which Conrad obtained his specimen. The most definite location was given by Dall (*Wagner Free Inst. Sci., Trans.*, vol. 3, pt. 4, p. 683, 1898) as "Miocene of Oyster Point, upper Rio Grande, near Roma, Mexico." Penrose (*Texas Geol. Survey, Ann. Rept.* 1, p. 46, 1890) apparently initiated the appellation "*Ostrea georgiana*?" for the large fossil oysters which occur near Roma. Whether he knew of Conrad's *O. contracta* is not apparent from his report. If *O. contracta* were described from the vicinity of Roma, it is probably upper Eocene in age. On the geologic map accompanying the recent report by Trowbridge (*U. S. Geol. Survey, Bull.* 837, 1932), Roma is shown to be situated on the outcrop of a formation termed "Fayette," though a few miles upstream another formation termed "Cockfield" outcrops. Trowbridge reports *O. georgiana* from the Cook Mountain (p. 117), Cockfield (p. 131) and Fayette (p. 143) formations. (For additional discussion of the oysters of the Rio Grande section, see Harris, 1919, and Gardner, 1923.)

NOTE 4.—Dr. B. L. Clark (*Calif. Univ., Dept. Geol. Sci., Pub.*, vol. 8, no. 22, p. 447, pl. 43, 1915) has shown *O. bourgeoisii* to be characteristic of the upper Monterey and lower San Pablo formations of central California and has pointed out that it is distinct from *O. titan*.

NOTE 5.—Use of the terms "Upper Chickasawhay" and "Lower Chickasawhay" as stratigraphic members is decidedly objectionable nomenclatural practice, in the view of the Editor, for it is stated by the author that the adjectives "Upper" and "Lower" do not indicate respective parts of a single member but rather are used to differentiate independent units of the same rank. It appears that the name Chickasawhay should be restricted to one of these members, and a new name introduced for the other.—R. C. Moore.

I have combined these two beds as the "Chickasawhay marl member of the Byram marl." (See Am. Assoc. Petroleum Geologists, Bull., vol. 19, p. 1166, 1935.) Whether it is Oligocene or Miocene depends upon where the line between Oligocene and Miocene is drawn. —C. Wythe Cooke.

NOTE 6.—The practice of designating a formation or zone by a generic term is undesirable. As an illustration, the "*Discorbis* zone" of the so-called "Middle Oligocene" of Applin, Ellisor and Knicker (*Am. Assoc. Petroleum Geologists, Bull.*, vol. 9, pp. 102, 103, 1925) was based, according to the authors, on *Discorbis vilardeboana* d'Orbigny, a species recently assigned by Cushman (*Scripps Inst. Oceanography, Bull., Tech. Ser.*, vol. 1, no. 10, p. 161, 1927) to the genus *Valvulineria*. Likewise the *Discorbis jacksonensis* var. *texana* zone, Jackson Eocene, of Cushman and Applin (*Am. Assoc. Petroleum Geologists, Bull.*, vol. 10, pp. 157, 158, 1926) was based on a foraminifer of that name, which has recently been assigned by its senior author (*U. S. Geol. Survey, Prof. Paper* 181, p. 51, 1935) to the genus *Anomalina*.

HENRY V. HOWE, LOUISIANA STATE UNIVERSITY, BATON ROUGE, LA. MANUSCRIPT RECEIVED BY THE EDITOR, SEPTEMBER 1, 1936.

PALEONTOLOGICAL NOTES

OPERCULINA IN THE LOWER TERTIARY OF WASHINGTON

J. WYATT DURHAM

A single specimen of *Operculina* has been found by me in shale that is commonly regarded as early Oligocene or late Eocene in age, on the north side of Willapa River bluff at bend to north, one-half mile east of Holcomb and some 300 yards west of bridge across river, Pacific County, Washington. This locality, at latitude ca. 46° 40′ N., is shown on the areal and structural geologic map of southwestern Washington by C. E. Weaver (1916). The associated fauna contains, among other megafossils, *Turcicula columbiana* Dall, *Epitonium condoni* Dall, *Acila* (*Truncacila*) *nehalemensis* Hanna, *Nemocardium weaveri* (Anderson and Martin), and *Conus* n. sp. All of these species are found in the Keasey formation at its type locality in Columbia County, Oregon, thus indicating the probable correlation of the beds at Holcomb with those of the type Keasey.

The single specimen (Fig. 1) measures 4 mm. in length; it is complanate, strongly compressed, and evolute; the

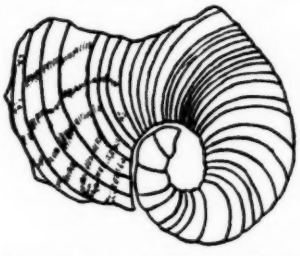

FIG. 1. *Operculina* sp. (×10) from late Eocene or early Oligocene shale near Holcomb, Washington. Stanford Univ., No. 6017.

early whorl is not visible because of matrix. The specimen appears to be closer to the genotype of *Operculina s.s.* than it is to the type of *Operculinella* or *Operculinoides*.

This is the second time that a specimen of the genus has been found in Tertiary strata of the Pacific Slope of North America. The first record is by Woodring (1930; see also 1931), who figured a specimen from an Eocene limestone in Cañada de los Sauces, Santa Barbara County, California. The formation carrying this specimen is older than the Keasey formation of Oregon, and, therefore, older than the beds carrying the *Operculina* herein noted.

The significance of this new northern record of *Operculina* is obvious when considered in the light of the numerous occurrences of the genus in the Japanese Empire (Hanzawa, 1935). Specimens of *Operculina* may contribute to demonstrating the Tertiary faunal relationships of the two regions, since the migratory route, as shown by any north polar projection map, is linear.

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J. WYATT DURHAM, MUSEUM OF PALEONTOLOGY, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA. MANUSCRIPT RECEIVED BY THE EDITOR, JUNE 15, 1936.

AECHMINA CRENULATA, NEW NAME FOR *AECHMINA SERRATA* STEWART, NOT CORYELL AND CUSKLEY

GRACE A. STEWART

Dr. H. N. Coryell has drawn my attention to the fact that the name *serrata* recently proposed by me for a species of the ostracode genus *Aechmina* (*Jour. Paleontology*, vol. 10, no. 8, p. 748, 1936), was used in 1934 by Coryell and Cuskley for a species of this genus (Coryell and Cuskley, *Am. Mus. Novitates*, no. 748, p. 6, fig. 6). Therefore I propose to substitute for *Aechmina serrata* Stewart, not Coryell and Cuskley, the new name *Aechmina crenulata* Stewart.

OHIO STATE UNIVERSITY, COLUMBUS, OHIO.

MARSHALL AVERY HOWE

THOMAS WAYLAND VAUGHAN

(With A Bibliography of His Papers on Calcareous Algae by Rosalie Weikert, New York Botanical Garden)

In the death of Dr. Marshall Avery Howe on the 24th of December, 1936, students of the formation of limestones and related geological problems suffered a heavy loss. Although Doctor Howe was interested in many groups of plants, particularly dahlias and other ornamentals, his research work was on hepatics and marine algae. As long ago as 1901 he began to publish papers on calcareous algae. Between 1901 and 1911 he published several papers on the living representatives of the green calcareous algae, the Codiaceae, and the red algae, the Rhodophyceae. In 1912 he published his first papers on calcium carbonate-secreting algae as constructional geological agents. It had been shown from the study of the Funafuti boring that calcareous algae in that particular bore were more important in the formation of limestone than corals. From a wide knowledge of calcareous algae Howe said in his article in Science (1912), "Full honors in this connection may yet go to the more humble lime-secreting plants."

Quantitative studies of the composition of calcareous sands at Murray Island, Australia (Goldman, 1918); in Pago Pago Harbor, Samoa (Bramlette, 1926); on Pearl and Hermes reefs, Midway (Thorp, 1936); and along the Florida and Bahama reef tracts (Thorp, 1935), showed that the quantities of material contributed to the bottom deposits by calcareous algae and corals were almost equal, or that coralline algae are dominant. Thorp says (1935, p. 93), "Coralline algae, collectively, are shown to be the organic group that makes the largest contribution of organically secreted calcium carbonate," along the coral reef tracts of Florida and the Bahamas.

Doctor Howe published his first paper on fossil calcareous algae in 1918, and his last paper on that subject appeared in June, 1934. These papers possess great scientific value, for they constitute the only critical scientific contributions on

calcareous algae contained in American Pleistocene, Tertiary, and Jurassic marine limestones. It is to be hoped that some one will continue this important work.

Doctor Howe was born at Newfane, Vermont, on June 6, 1867; he graduated at the University of Vermont in 1890; and received his Ph.D. degree at Columbia in 1898. From 1901 until his death he was a member of the staff of the New York Botanical Garden, and during the last fifteen months of his life he was the Director of the Garden.

Doctor Howe received high recognition for his scientific achievements. The University of Vermont conferred on him the honorary degree of Doctor of Science; and he was a member of the National Academy of Sciences and of many technical scientific societies.

Doctor Howe possessed a quiet, unobtrusive, but delightful personality. One of his characteristic traits was his ever readiness to help his scientific colleagues. He was generous to a fault. For the author of this notice he wrote four scientific papers; and he put up and labeled a typical set of specimens representing the principal species of calcareous algae from Florida and the West Indies. This valuable reference collection is now at the Scripps Institution of Oceanography, La Jolla, California. To have known Doctor Howe was a pleasure and an inspiration. His friends will always miss him.

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SOCIETY RECORDS AND ACTIVITIES

ELEVENTH ANNUAL MEETING OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

President, M. C. Israelsky, in the chair
Vice-President, R. W.Harris (absent)
Secretary-Treasurer, Gayle Scott (absent)
Editor, R. C. Moore (absent)

The eleventh annual meeting of the Society of Economic Paleontologists and Mineralogists was held in the Biltmore Hotel, Los Angeles, California, Thursday, March 18, 1937, in conjunction with the regular annual meeting of the American Association of Petroleum Geologists, also held at the Biltmore Hotel, March 17–19, 1937.

The morning session was called at 9:00 a.m. for presentation of papers, Mr. Boris G. Laiming presiding. A symposium on California Cretaceous and Tertiary stratigraphy and paleontology was given. Mr. Stanley G. Wissler presided over the afternoon session, which was composed of general technical papers. The program was as follows:

PROGRAM

Symposium on California Cretaceous and Tertiary Stratigraphy and Paleontology

Cretaceous: Leader, PAUL P. GOUDKOFF.

1. PAUL P. GOUDKOFF. The Cretaceous of the Central Valley of California.

Eocene: Leader, FRANK B. TOLMAN.

2. FRANK B. TOLMAN. Review of the California Eocene.

Oligocene: Leader, HUBERT G. SCHENCK.

3. LESH C. FORREST. The Type San Lorenzo.
4. BRUCE L. CLARK. The Oligocene of Contra Costa County.
5. E. R. ATWILL. The Type Tumey Formation.
6. R. M. KLEINPELL. The Gaviota Pass Section.
7. CHESTER STOCK. Early Tertiary Mammal Faunas of Southern California.
8. HUBERT G. SCHENCK. The Significance of *Lepidocyclina* in California.

Miocene: Leaders, R. M. KLEINPELL and W. D. RANKIN.

9. ROBERT M. KLEINPELL. The Miocene of Central California.
10. WILBUR D. RANKIN. The Miocene of Southern California.

Post-Miocene: Leader, HERSCHEL L. DRIVER.

11. HERSCHEL L. DRIVER. Correlation of Oil Fields Within Los Angeles Basin, California.
12. W. H. HOLMAN. The Stratigraphic Relations of Pliocene Sections of the Los Angeles District.
13. WILLIAM F. BARBAT. The Post-Miocene of the Maricopa Basin (Southern San Joaquin Valley).
14. BRADFORD C. ADAMS. The Pliocene of the Ventura Basin.
15. U. S. GRANT. Some Observations on the Pleistocene of the Los Angeles Region.
16. MANLEY L. NATLAND. The Distribution of Recent and Later Tertiary Foraminifera in Southern California.

General Technical Papers

17. MERLE C. ISRAELSKY. Gulf Coast Markers in the Eocene of Marysville Buttes, California.
18. W. P. WOODRING. Paleogeographic Implications of the Larger Fossils From the Repetto Formation of the Los Angeles Basin, California.
19. CHARLES R. CANFIELD. The Subsurface Stratigraphy and Micropaleontology of the Santa Maria Valley, California.
20. DONALD W. GRAVELL and MARCUS A. HANNA. A New Horizon, *Lepidocyclina* (*Lepidocyclina*) *texana*, Gravell and Hanna n. sp. Ms., in the *Heterostegina* Zone, Upper Oligocene, of Texas and Louisiana.

21. STANLEY G. WISSLER. Foraminiferal Zones of the Dominguez Oil Field, Los Angeles County, California (By title).
22. H. L. DURGAN. Species of the Genus *Cytheropteron* from the Weno Formation (Middle Washita) of Southern Oklahoma and Northern Texas. (By title)

BUSINESS MEETING

The business meeting was held immediately following the last paper of the technical session, the following items being considered:

1. President Israelsky informed the group of Secretary Scott's inability to serve during the coming year.

2. It was moved, seconded, and carried that reading of the minutes of the previous meeting be omitted.

3. The report of the Secretary-Treasurer was read and the supplementary audit accepted.

4. It was moved by G. D. Hanna that a vote of thanks be extended to Secretary-treasurer Scott for his services to the Society. The motion was seconded and carried unanimously.

5. The Society voted in favor of the acceptance of the new constitution.

6. Dr. J. B. Reeside, Jr., and President Israelsky discussed the joint publication plan with the Paleontological Society, bringing out the success and harmony of the plan during the past year.

7. There followed a discussion by President Israelsky of the S.E.P.M. sponsoring the publication of larger papers by the A.A.P.G. He suggested that the Society's sponsorship be limited to papers on micropaleontology. The paper on Miocene Foraminifera of Reliz Canyon by R. M. Kleinpell was suggested by several as a paper worthy of sponsorship. Laiming mentioned that Kleinpell's paper was much more comprehensive than the title would indicate and emphasized the need of this paper by workers in California. Mr. Donald D. Hughes moved that "The council of the S.E.P.M. be empowered to consult with the officers of the A.A.P.G. as to the special publication by the A.A.P.G. of micropaleontologic papers having a stratigraphic significance." The motion was seconded and carried unanimously.

8. Mr. F. B. Plummer was nominated for honorary membership in the S.E.P.M. by President Israelsky on behalf of the council and was unanimously elected.

9. The following report of the Resolutions Committee was read and adopted:

Be it Resolved, That we, as members of the Society of Economic Paleontologists and Mineralogists, express our gratitude and appreciation of the many individuals and organizations who have contributed to the success of the Los Angeles, California, meeting, especially to the following: (a) The A.A.P.G. for their liberal grant to the Journal of Paleontology. (b) Ralph Reed and other Association officers for their willing cooperation. (c) Stanley Wissler, Herschel Driver, and Boris Laiming for the excellent program arrangement and commodious meeting room. (d) We extend to Gayle Scott our hopes for a rapid recovery and express the Society's regret at the loss of his services.

J. B. REESIDE, JR.
F. W. ROLSHAUSEN

10. The election ballots were opened and President Israelsky announced the results:

President: Stanley G. Wissler
Vice-President: F. W. Rolshausen
Secretary-Treasurer: H. V. Howe
Editor: R. C. Moore

11. The meeting was adjourned.

FRANK W. BELL
Acting Secretary

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

A DIVISION OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

CONSTITUTION

ARTICLE I. NAME

The Society shall be known as the Society of Economic Paleontologists and Mineralogists.

ARTICLE II. OBJECT

The object of the Society shall be to promote the science of stratigraphy through research in paleontology and sedimentary petrology, especially as these relate to development of knowledge of the geology of petroleum.

ARTICLE III. MEMBERSHIP

1. The Society shall be composed of members, associate members, honorary members, correspondents and patrons.

2. Members shall be persons engaged in paleontologic, petrographic or stratigraphic studies as applied to the geology of petroleum and who have been duly elected members or associate members in the American Association of Petroleum Geologists.

3. Associate members shall be other persons engaged in paleontologic, petrologic or stratigraphic studies that have application to the geology of petroleum.

4. Honorary members shall be persons of distinguished achievement whose contributions to paleontology, petrology and stratigraphy have an application to the geology of petroleum.

5. Correspondents shall be persons not resident in North America who have made distinctive contributions to paleontology, petrology, and stratigraphy that have application to the geology of petroleum.

6. Patrons shall be persons who have bestowed important favors on the Society.

ARTICLE IV. OFFICERS

1. Executive authority of the Society is vested in a Council consisting of five members duly elected officers, as follows: President, Vice-President, Secretary-Treasurer, and the two most recently retired past-presidents.

2. The President shall discharge the usual duties of a presiding officer at all meetings of the Society and Council.

3. The Vice-President shall assume the duties of the President in case of his absence.

In the event of the absence from the meetings of both President and Vice-President the duties of presiding officer shall fall upon one of the other members of the Council in the following order: most recent Past-President, second most recent Past-President, Secretary-Treasurer.

4. The Secretary-Treasurer shall keep record of the proceedings of the Society, and a complete list of the membership. He shall attend to the preparation and mailing of notices and other materials required in the business of the Society. The Secretary-Treasurer shall have custody of all funds of the Society, and shall keep a detailed account of receipts and disbursements.

5. The Council has legislative powers of the Society in the intervals between meetings, provided that all legislative acts of the Council shall be subject to the review of the Society at its next following meeting. The Council shall receive nominations for members and associate members, election requiring favorable vote of four members of the Council, and shall have the power to make nominations for honorary members, correspondents and patrons. The Council shall have power to fill vacancies ad interim in any of the offices of the Society.

6. Elections shall be held annually to select a President, Vice-President, and Secretary-Treasurer.

ARTICLE V. MEETINGS

1. The Society shall hold at least one stated meeting a year, which shall be designated as the annual meeting. The time and place of the annual meeting shall be designated by the Council, but, in general, it shall be held in connection with the annual meeting of the American Association of Petroleum Geologists.

2. The annual meeting shall be devoted to the reading and discussion of scientific papers, to the transaction of Society business, and other appropriate functions.

3. The program for the annual meeting shall be arranged by the Council, or under its directions.

ARTICLE VI. PUBLICATIONS

The Council is authorized and directed to make such arrangements for publication and distribution of scientific contributions in the fields of paleontology and sedimentary petrology as the financial resources of the Society permit, provided that no important actions involving publication policy shall be taken or be deemed effective without approval of the membership of the Society.

ARTICLE VII. SECTIONS

Local sections of the Society may be established according to provisions of the by-laws.

ARTICLE VIII. AMENDMENTS

This Constitution may be amended by a two-thirds majority vote of returned mail

ballots received by the Secretary-Treasurer sixty days after proposal of amendments with provision for vote is mailed to the membership; provided that the proposed amendment has been signed by at least twenty members, and provided further that the proposed amendment has received the approval of the Executive Committee of the American Association of Petroleum Geologists before it is submitted to vote.

BY-LAWS

Article I. Membership

1. All members and associate members of the American Association of Petroleum Geologists in good standing who are interested in the geology of petroleum may, on application to the Council of the Society, be elected as members.

2. Persons not members or associate members of the American Association of Petroleum Geologists may, on recommendation of two members of the Society, be elected by the Council to associate membership.

3. Honorary members may be nominated by a vote of four members of the Council and such nomination shall be submitted to the members by mail ballot. Providing eighty percent or more of the returned ballots are favorable, the nominee shall be declared elected.

4. Correspondents shall be nominated and elected in the manner prescribed for honorary members.

5. Patrons shall be nominated and elected in the manner prescribed for honorary members.

Article II. Duties and Privileges of Members

1. Members and associate members shall pay annual dues to the Society in the amount of two ($2.00) dollars, such dues to be payable to the Secretary-Treasurer on January 1 of each year and to be applied to the calendar year following this date, provided that a member shall not be deemed in arrears until December 31 of the year for which no dues have been paid, provided further that dues of members who are also members or associate members of the American Association of Petroleum Geologists may be credited as paid if and when this Association allots funds to the Society sufficient to cover these dues.

2. Members and associate members dropped for non-payment of dues may apply to the Council for reinstatement, and providing settlement is made of any outstanding indebtedness for publications and other charges approved by the Council, may be reinstated by vote of four members of the Council.

3. Honorary members, correspondents, and patrons shall not be required to pay annual dues.

4. Members shall be eligible to receive publications of the Society at special subscription rates as authorized by the Council or as provided in these by-laws.

5. The Council is authorized to transmit without charge such publications as it may direct to honorary members, correspondents, and patrons.

6. Only members in good standing shall have the right to vote in electing officers and in transacting the business of the Society.

Article III. Officers

1. Nominations for officers shall be made in the following manner. Prior to September 1 of each year, the President shall designate two nominating committees, instructing each committee to submit nominations for president, vice-president, and secretary-treasurer, these nominations to be in the Secretary's hands before September 15. If desired, the same person may be nominated by the two committees for the office of secretary-treasurer, but nominations for president and vice-president shall not include the name of the same person on the two slates. The nominations of the first committee to file its report will have precedence in case of overlapping nominations and the other committee shall then be requested to change its nomination.

2. Ballots containing the nominations for officers, alphabetically arranged under each office, shall be prepared by the Secretary-Treasurer and mailed to each member of the Society on or before October 1. Neither the ballot nor the enclosing envelope need contain the name of the voting member, but an outer envelope that contains the sealed ballot must bear the name of the voting member. The returned ballots received by the Secretary-Treasurer on or before December 1 shall be canvassed by him, and if requested, shall be submitted to recanvass by the Council. A plurality of the votes received for any office constitutes election.

3. The officers shall assume the duties of their respective offices immediately after the annual meeting in which the results of the election are announced.

Article IV. Publications

1. The Council is authorized and directed to make such arrangements for editorial preparation of manuscripts, publication and the distribution and general business management of publications as it shall deem desirable in the Society's interest. This includes designation of an editor or editors, who shall serve at the pleasure of the Council in the formulation of publication policies, making of contracts for printing and engraving, entering into agreements with other scientific societies for joint publication or joint management of publications, providing methods for keeping

of accounts, acceptance of advertising at determined rates, fixing subscription rates to non-members, and all other proper matters connected with efficient handling of publications of the Society not provided for in the Constitution.

2. *The Journal of Paleontology* is designated as an official publication of the Society, and the subscription rate to members shall be four ($4.00) dollars per year.

3. *The Journal of Sedimentary Petrology* is designated as an official publication of the Society, and the subscription rate to members shall be two ($2.00) dollars per year.

4. A publication fund shall be established consisting of an assignment of a portion of dues as designated by the Council, and the donations made to aid publication. The Council is authorized to provide for special publications from this fund as may be deemed desirable, and to fix terms for sale or other distribution of these publications.

5. The Council is not authorized to initiate and publish periodicals other than the *Journal of Paleontology* and the *Journal of Sedimentary Petrology.*

Article V. Financial Methods

1. No financial obligations shall be contracted without express sanction of the Society or Council, but all ordinary incidental running expenses have sanction without special action.

2. Statements of accounts charged to the Society, other than miscellaneous running expenses, shall be approved by the President before the Secretary-Treasurer pays the amount out of funds of the Society not otherwise appropriated, and the receipted bill shall be held as the Secretary-Treasurer's voucher.

3. At each annual meeting the President shall call on the Society to choose two members who are not members of the Council to whom shall be referred the books of the Secretary-Treasurer, duly posted and balanced. The auditors shall examine all accounts and vouchers and render a report to the meeting of the Society.

Article VI. Business Representatives

1. The President and the Secretary-Treasurer of the Society shall act as business representatives of the Society in the General Business Committee of the American Association of Petroleum Geologists. These representatives shall conduct such business with the Executive Committee of the Association as is of mutual interest to the Society and the Association in the interims between the annual meetings of the Society and the Association. Approval of the action of these representatives on the part of the Society during any year is reserved to the Council in session at the annual meeting at the close of that year. Questions remaining unsettled between the representatives of the Society and the Executive Committee of the Association shall be considered in a joint meeting of the Council of the Society or its authorized representatives and the Executive Committee of the Association at the annual meeting of the Association at the close of the interim period during which such questions have arisen.

Article VII. Sections

1. The establishment of local sections of the Society may be authorized by unanimous vote of the Council approving a petition for such establishment signed by ten members of the Society. Such local sections may elect officers, conduct meetings, and engage in other scientific activities, but shall not be entitled to special representation in general Society affairs.

2. The Council is authorized and directed to withdraw the charter of any established local section if there is evidence that it has become inactive.

Article VIII. Amendments

1. These by-laws may be amended at any annual business meeting by two-thirds vote of the members present, or by mail ballot sent to the members, in which case two-thirds of the returned ballots received in sixty days must approve the amendment in order to make it effective.